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Abstract

We present estimates of productivity growth for six energy intensive industries in India. We investigate aluminium, cement, fertiliser, glass, paper, iron and steel sectors as well as total manufacturing covering the period 1973-93. This work is part of a larger effort to study the energy sector of developing countries at the disaggregated level in order to arrive at more reliable estimates of AEEI parameters. The available estimates in the literature are marked by wide inter- and intra-industry variation, and thus are unhelpful in forming a judgement about the nature and extent of productivity growth. Our work is a partial response to the need for estimating productivity growth in a consistent and comparable framework with a common methodology and time period of study for all industries.

We use a growth accounting approach to decompose growth of output in terms of growth of inputs and a residual. The residual is attributed to growth in productivity of input factors. Assuming that the production function for Indian industries is not separable in terms of factor and non-factor inputs, we consider four inputs, i.e. capital, labour, energy and materials. This approach is in contrast with the conventional two input framework, where growth of value added is decomposed in terms of growth of labour and capital. Total productivity growth has been estimated by three alternative indices: (i) the Kendrick index, (ii) the Solow index, and (iii) the Translog index. Our estimates reveal variation in the nature and magnitude of productivity growth across industries. Over the two decades, 1973-93, aluminium, iron and steel and paper industries show negative productivity growth, while cement and glass industries record positive but low growth. In contrast, the fertiliser industry shows significant improvement in productivity. For the manufacturing industry as whole low productivity growth is indicated. These variations in part reflect differing responses to changes in economic policies, which are not yet fully understood. Our overall conclusion from the growth accounting approach is that the presumably rapid growth of energy demand is unlikely to be significantly moderated by productivity growth. However, in order to derive general policy implications a more thorough understanding of the rate and direction of technological change should be gained. This indicates a need for further research on the analysis of inter-input substitution processes and the effects of factor price changes that are specific to the Indian economy.

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1. Introduction

The importance of productivity growth for economic growth in developing countries is well recognised. These countries face acute shortage of resources and, therefore, output expansion based on increasing use of resources is not sustainable. In the existing literature on productivity growth, the emphasis has been on the productivity of capital and labour. This is not surprising because of the strategic place which expansion of physical capital occupied in the development doctrine of the fifties. Over the years, energy has been recognised as a critical factor constraining economic growth. This constraint can arise independently of the capital constraint or in conjunction with it. It is, therefore, necessary that d productivity growth be analysed in a framework where energy is explicitly accounted for.

The objective of this paper is to present estimates of productivity growth in India's energy intensive industries. These industries are: Aluminium, Cement, Fertiliser, Glass, Iron and Steel, and Paper. In a recent survey of productivity growth in these industries[1], it was found that there was a wide variation in the available estimates by different authors. This was true of estimates both within and across industries. Consequently, it could not be said unambiguously whether there had in fact been any productivity growth in this sector or not. This variation could be attributed to differences in methodology, measurement schemes for output and inputs, deflation procedures, time period of study and also because of methods of averaging or reporting growth rates.

It was felt, therefore, that there was a need for estimating productivity growth in these industries, in a consistent and comparable framework. The framework would have a common methodology and the same time period of study for each of these industries. This paper is a contribution towards fulfilling that need.

The plan of this paper is as follows. In the next section we outline our methodology for estimating productivity growth. In section 3 we explain sources of data and method of construction of variables. Section 4 contains remarks to how to interpret estimates. Sections 5 contains estimates of productivity growth for aggregate manufacturing. Sections 6 to 11 present estimates for the six industries. Finally, section 12 contains concluding observations.

2. Methodology

We take productivity growth to mean the excess of growth of output over that of input(s) over time. In this study, we have estimated indices of partial and total productivity in the framework of a four input production function:

$$Y = Y (K, L, E, M)$$

Where Y is output and K, L, E and M respectively indicate capital, labour, energy and material inputs.

[1] Mongia P. and J. Sathaye (1997) Productivity Growth in India's Energy Intensive Industries: A Survey, Lawrence Berkeley National Laboratory.

This framework differs from the one adopted in conventional studies on productivity growth. In those studies, output is identified with value added and the two inputs in the production function are capital and labour. The choice between one framework and the other depends on whether or not one can assume a production function to be separable in terms of factor and non-factor inputs. When energy and material inputs cannot be considered separable from capital and labour inputs, the value added form of production function cannot be used. Following the neo-classical tradition, productivity growth literature in India, till recently, has assumed value added form of production function. In a recent study, Pradhan and Barik (1998) have statistically tested for the separability of material inputs and capital and labour inputs for aggregate manufacturing and for eight individual industries in India. They found that value added functional form is not appropriate.

Since, our focus is on energy, we assume without formal testing that production technology in India's manufacturing sector as well as in individual energy intensive industries can be represented by the four input production function given above.[2]

Partial or single factor productivity for any input is calculated by the ratios of output to individual inputs Y/K, Y/L , Y/E and Y/M. These ratios can be interpreted as average product of the relevant input. An increase in this ratio over time indicates productivity growth or input savings. The inverse of a ratio indicates factor intensity.

It is well known that partial productivity indicators by themselves can be misleading. An increase in one ratio may actually reflect not a genuine productivity increase but actually an increase in the use of another factor. Thus increased labour productivity may actually be a result of capital deepening or an increase in K/L ratio. The partial productivity growth measures need to be supplemented by measures of total productivity growth.

Total productivity is measured by the ratio of output to a weighted combination of inputs. Consequently, total productivity growth is the excess of growth of output over the growth of the weighted combination of inputs.

In the present study, total productivity growth has been estimated by three alternative indices. These are (i) Kendrick index, (ii) Solow index and (iii) Translog index.[3]

a) To recapitulate, Kendrick index (A_t) for the four factor input case is given by:

$$A_t = \frac{Y_t}{\left(s_K . K_t + s_L . L_t + s_E . E_t + s_M . M_t\right)}$$

Where ,

[2] For an earlier representation in this form, see Williams and Laumas (1981).

[3] The algebraic formulation as well as relative merits and demerits of these measures have been explained in the Survey mentioned in the previous paragraph.

A_t is the value of index in a given year,

Y_t is the value of gross output,

s_j (j = K,L,E,M) indicates the share of j th factor in the value of gross output.

This index is a fixed weight index. The factor shares used as weights are base year shares. For purpose the purpose of this study, factor shares were taken as average of (current price) shares for the first three years.

From the Kendrick index arrived at by the above formula, yearly growth series (g_t) was formed by writing
$g_{t+1} = (A_{t+1} - A_t) / A_t$.

b) Solow measure of productivity growth is given by

$$g_{t+1}^{S} = \left[\frac{Y_{t+1} - Y_t}{Y_t}\right] - \left[\sum_j s_j^t - \left(\frac{I_{t+1}^j - I_t^j}{I_t^j}\right)\right]$$

Where,
Y_j = measure of output,
s^j_t = share of j th input in year t.
I^j = j th input, j = K,L,E,M.

Assuming $A_1 = 1$, Solow index of productivity (A_t)was formed from the formula:

$A_{t+1} = A_t * (1+ g^S_{t+1})$

c) Translog measure of growth is given by

$$g_{t+1}^{T} = \ln\left[\frac{Y_{t+1}}{Y_t}\right] - \left[\sum_j \frac{\left(s_{t+1}^j + s^j\right)}{2} * \ln\left(\frac{I_{t+1}^j}{I_t}\right)\right]$$

Where ln indicates natural log operator. All other symbols have the meaning as above in the Solow measure. An index is formed by assuming $A_1 = 1$ and writing

$A_{t+1} = A_t \exp (g^T_{t+1})$

Currently, the translog measure is the most preferred measure for productivity growth. In what follows, the growth experience is described and analysed in terms of the Translog index. Other indices are reported to facilitate comparison with other studies and also to ensure that estimates do not reflect measure specific biases.

There are three alternative ways in which productivity growth can be summarised: (i) take simple unweighted averages of the year to year growth rates, (ii) estimate the trend rate of growth

(trog) by fitting a semi-logarithmic regression of the relevant time series of productivity indices, and (iii) estimate compound annual growth rates (cagr) between observations at the beginning and at the end of each series.

For this study, we estimated productivity growth using all these approaches. We calculated compound growth rates by the third method above. For this purpose, the beginning and the ending observations were three year averages of the relevant time series. In addition to these we also estimated trend rates of growth described above. The two procedures gave remarkably similar results. While the former were used to report the growth experience, the latter were estimated to facilitate comparison with other studies. These are included in an Appendix. In addition to these simple unweighted averages of the year to year growth rates were estimated and reported wherever necessary.

The period of this study extends from the years 1973 to 1993. The choice of the beginning year was dictated by the fact that due to a change in the data collection procedure, data for earlier years was not comparable. The ending year was chosen solely because it was the last year for which published data was available.

In this study, growth rates are estimated for the years 1973 -1993 and for two sub-periods 1973-81 and 1981-93. The choice of sub-periods is dictated by the perceived impact of change in industrial policies in 1973 and 1977 and their effect on output and productivity growth in the eighties. Ahluwalia (1991) in her study on productivity growth has suggested that after a prolonged period of industrial stagnation which began in mid-sixties, there was a turnaround in output growth around the year 1980-81. This was a result of the re-orientation of policies following the industrial drift. During this period, rising fiscal deficit, led to growth of demand for industrial products. Investment in and toning of infrastructure facilitated the supply response to meet the increased demand. There is a controversy about the existence and timing of the turnaround because of methodological differences and ideological perspectives.[4] Disregarding the controversy, it can still be said that productivity growth in the second period was qualitatively and quantitatively different from that achieved in the first part.

3. Sources of data and construction of variables

The data for estimating indices of productivity growth was taken from the Annual Survey of Industries (ASI, Summary results for factory sector) published by the Central Statistical Organisation, for the years 1973-93. There was a change in the classification of industries followed in the ASI in 1988-89. Before that date ASI followed National Industrial Classification, 1970 (NIC-1970). From 1989-90, ASI switched over to NIC-1987. Table 3.0 indicates the scope of coverage over time:

Data on wholesale prices for deflating nominal value series, were obtained from the Office of Economic Adviser, Ministry of Finance, and from Chandok (1990). We also used the CSO's Input Output Table of India 1983-84 for estimating shares of major inputs in the different sectors of our study for constructing price deflators for material inputs.

[4] See for example Balakrishnan and Pushpangdan (1996).

Table 3.0: Coverage of Industry Codes

Industry Name	NIC-1970 Code (Till 1988-89)	NIC-1987 Code (After 1988-89)
1. Aluminium	335	335
2. Cement	324, 328	324, 327
3. Fertiliser	311	301
4. Glass	321	321
5. Iron and Steel	330	330
6. Paper and paper products	280,281,282,283	280,281,282,283

Following are the definitions for values and their correspondence in terms of the ASI data:

Output: Gross output at constant prices has been adopted as a measure of output. Gross output is defined to include the ex-factory value of products and by-products manufactured during the accounting year. It also includes the receipt for industrial and non-industrial services rendered to others, value of semi-finished goods of last year sold in current year, value of electricity sold, and sale value of goods sold in the same conditions as purchased.

Capital: Gross fixed capital has been used to represent the factor capital. Fixed capital represents the depreciated value of fixed assets owned by the factory as on the closing day of the accounting year. Fixed assets are those which have a normal productive life of more than one year. Fixed capital covers all types of assets, new or used or own constructed, deployed for production, transportation, living or recreational facilities, hospitals, schools etc., for factory personal. It includes the fixed assets of the head office allocable to the factory and also the full value of assets taken on hire-purchase basis (whether fully paid or not) excluding interest element. It excludes intangible assets and assets solely used for post manufacturing activities such as sale, storage, distribution etc.

Ideally one should arrive at capital stock in each year using the perpetual inventory method by retiring some capital each year and adding the amount of gross fixed capital formation beginning with some base year estimates. But this procedure could not be adopted due to lack of base year data for capital stocks in different industries.

Labour: The number of employees was used to represent labour for the years 1973 to 1988 and total persons engaged thereafter. Employees include all workers and persons receiving wages and holding supervisory or managerial positions engaged in administrative office, store keeping section and welfare section, sales department as also those engaged in purchase of raw materials, etc. or production of fixed assets for the factory and watch and ward staff.

Energy was represented by the item fuels consumed in the ASI. Fuels consumed represent total purchase value of all items of fuels, lubricants, electricity, water etc. consumed by the factory during the accounting year including gasoline and other fuels for vehicles except those that directly enter into products as materials consumed. It excludes quantities acquired and consumed from allied concerns, their book value being taken as their purchase value and also the quantities consumed in production of machinery or other capital items for factory's use.

Materials: Material inputs were represented by the item Materials Consumed in the ASI. Materials consumed represent the total delivered value of all items of raw materials, components, chemicals, packing materials and stones which actually entered into the production process of the factory during the accounting year. Also, it includes the rate of all materials used in the production of fixed assets including construction work for factory's own use.

Factor Shares: Wage share of labour was approximated by dividing the Total Emoluments by the number of total persons engaged. Shares of energy and materials were obtained by dividing their value by the value of output. The share of capital was then obtained as a residual.

Constant price series: ASI reports different series on output and inputs at current prices for the relevant years. By deflating these series with appropriate deflators, we arrived at the constant price series for them. The value of output of different industries was deflated by the appropriate i.e. commodity/ sector specific wholesale price index (WPI). These were obtained from different volumes of the "Index Numbers of Wholesale Prices in India". The index numbers for the years 1973-74 to 1980-81 were available in these volumes with the base year 1970-71, and for the remaining years with the base year 1981-82. By using appropriate linking factors calculated from the figures common to both series, a new series of WPI's was calculated with the year 1973-74 as the base year. These were then used for deflating the output of different industries. Deflators used for different industries are given in Appendix A.

The fixed capital series was deflated by the wholesale price index of machinery and machine tools including electrical machinery, after converting this wholesale price index to the base year 1973-74.

The number of total persons employed are taken in absolute numbers.

The series on fuels consumed has been deflated by the wholesale price index for fuel, power, light and lubricants.

In order to deflate the series on materials consumed we have constructed industry specific material price indices. Using the input-output table (1989-90) the components of materials for each industry were identified, and their proportions to total materials consumed calculated. Using these figures as weights, WPI's of various inputs have been combined to construct the appropriate material price index for each industry. Material inputs and their proportions are listed in Appendix B.

4. Estimates and their Interpretation

In the following sections we present estimates of partial and total productivity growth. Since the growth performance of any series must take into account differences in the size and the structure of different industries, we begin each section with a look at the broad orders of magnitude for the six industries. The estimates are followed by an attempt to relate them to policy changes. This is not an easy task and a word of explanation is in order. Total productivity

growth was defined above as growth of output in excess of growth of inputs. As Ahluwalia explains, the contribution of inputs to increase in output is measured by the production function. Total productivity growth, therefore, is indicative of a shift in the production function itself. This shift can be seen as a result of combined effects of pure technical progress and the growth in overall efficiency with which factors are combined. It would thus include shifts arising out of the use of improved machines or better maintenance procedures. It may incorporate the effect of improved training and experience (learning by doing) on the quality of labour. It may reflect better organisation skills and better labour management relations. Above all, it may reflect better utilisation of capacities.

While one can visualise or even observe the influence of many of the factors mentioned above, it is not always possible to measure them in terms of conventional economic variables. Further, it is not easy to identify them with specific policies and work out their influence on observed instances or phases of productivity growth.

It may be observed that productivity growth and output growth are strongly related. As output grows, industries are able to utilise their existing installed capacity more fully. This directly helps increase productivity. If output expansion induces capacity expansion, the additional capacity may consist of processes and technologies which are inherently more efficient or productive. An output expansion phase which persists may help increase productivity by enabling them to exploit economies of size and scale.

Therefore, a large part of the explanation of what causes productivity growth lies in finding what causes output growth. When explaining productivity growth in individual industries in the following sections, we will try to distinguish between factors which relate to overall industrial and economic environment and those which relate to the specific industry.

Before we present the estimates and their interpretation, we present a brief perspective on Indian industrial policy.

Productivity growth during 1973-93 needs to be put in the perspective of the policy environment prevailing at the time. The period was marked by policies which were aimed at de-regulation, decontrol and progressive liberalisation of the economy. Beginning with the Industrial Policy Statement (IPS), 1973, the period was characterised by wide ranging reforms of the industrial sectors. The statement reflected fundamental changes in economic thinking of the government from policies pursued earlier with respect to industrialisation. For the first time, steps toward liberalisation were openly taken. Government published a consolidated list of industries which were opened up for the participation of larger industrial houses along with other applicants (i.e. industrial houses whose assets are worth more than Rs. 20 crores) and branches and subsidiaries of foreign companies. This list included core industries and industries with a long-term export potential which were earlier reserved only for the public sector. Special reservations were made for the small and medium sectors.

A concept of joint sector was introduced to encourage collaboration between public and private sectors. Multinational companies and their subsidiaries were made eligible to apply for

licensed capacity, to increase the inflow of foreign resources. Increasing emphasis was placed on productivity and profitability in industrialisation. The absorption of foreign capital and foreign technology was viewed more favourably.

In 1975-76, important changes were made in the sphere of industrial licensing to stimulate investment in the priority sectors and to ensure fuller utilisation of installed capacities. Government de-licensed 21 industries, the exceptions being the firms covered by the MRTP Act or FERA. In addition, medium enterprises in 29 specified industries were allowed to use their existing installed capacity without limit even though this may be in excess of their licensed capacity. This facility was extended to MRTP and FERA companies if the production was meant for exports.

During 1976-77 further relaxation was made in the sphere of industrial licensing. A number of industries were permitted to increase their production by 25% subject to certain conditions about technological upgradation, modernisation and export development. IPS 1977, put the emphasis on revival and growth of small-scale and cottage industries to generate more employment. In 1980, the emphasis shifted back on modernisation, and expansion with the need for a balance being struck between employment generation and optimum utilisation of capacity. Government took various steps to encourage large volumes of production including broad-banding, mergers of firms and special measures to revive sick units.

In 1985, the government de-licensed 25 broad categories of industries and extended this to MRTP and FERA companies. This was followed by the new Long Term Fiscal Policy which complemented the industrial policies through rationalisation of taxation.

The policy scenario was dominated by a host of measures that facilitated capacity creation, output expansion and reduction of the procedural impediments. In 1991, after a severe balance of payment crisis, government realised that macro-economic stabilisation and fiscal adjustment alone would not suffice. It announced far reaching measures at structural adjustment in the overall economic policy. The government decided to increase the efficiency and international competitiveness of industrial production by encouraging foreign investment and technology. Simultaneously it took measures to remove barriers to entry and limits on economic growth in the size of firms in the domestic economy. To bring about improvement in productivity, several measures were undertaken to encourage competition in the domestic economy. The past import substitution policy was replaced by the new export promotion policy.

The effect of changes in policy was not uniform for all industries, as we will see in the following sections on productivity growth in energy intensive industries. Also, the time lag of response to changes in policy measures was different for different industries.

5. Aggregate Manufacturing

In this section we present estimates of total productivity for aggregate manufacturing. Manufacturing sector is a major consumer of energy in India. In 1993-94 it accounted for 27 % of the GDP and 40 % of the total energy consumed. Output and inputs in the aggregate manufacturing at the beginning and at the end of the period of our study are given in Table 5.0.

Table 5.0: Output and Inputs: Aggregate Manufacturing

Average	Output	GVA	Capital	Labour	Energy	Materials
1973-75	2188019	571374	999465	6084553	97482	1299550
1991-93	8361241	1956803	4020369	8664410	393310	5081122

Notes:
Figures are in const (1973-74 values) lakhs of Rupees, except labour and factories which are numbers.
Figures are averages for three years at the beginning and end of the period of study. For the construction of material price index for deflating material price index for aggregate manufacturing, see note at the end of this section.

Energy costs on an average constituted 4.7 per cent of the value of output (and 20.10% of GVA) during 1991-93. The comparative figures for the beginning of the period were 4.46% and 17.06% respectively.

The indices of real value of output and inputs are shown in Figure 5.0 while their growth rates are shown in Table 5.0a.

Figure 5.0: Real Output and Inputs Indices: Aggregate Manufacturing

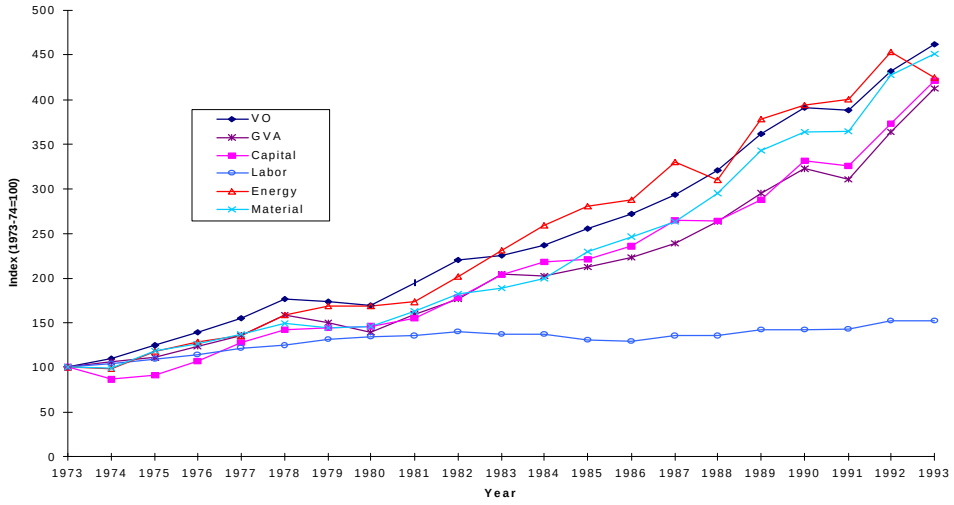


Table 5.0.a: Growth of Output and Inputs : Aggregate Manufacturing

Year	Output	GVA	Capital	Labour	Energy	Materials
1973/75 - 80/82	8.25	5.98	8.07	3.93	8.05	6.39
1980/82 - 91/93	7.40	7.78	8.02	0.76	8.07	8.82
1973/75 - 91/93	7.73	7.08	8.04	1.98	8.06	7.87

Note: Figures are compound annual growth rates between the three year periods for which average values for the relevant parameters were taken.

During the years 1973-93 output grew at the annual rate of 7.73 per cent. This was accompanied by a 8.04 % per annum growth in the stock of gross fixed capital and 1.98% per annum growth in the labour force. Energy and materials consumption grew at the rates of 8.06

and 7.87 per cent per annum respectively. The implied elasticity of energy consumption with respect to output was 1.04 and with respect to value added 1.14.

The growth of output and inputs were not uniform over time. In the first sub-period, output grew at the rate of 8.25 per cent per annum and increased to a rate of 7.40 per cent per annum in the second period. The rates of growth of both capital and labour slowed down during the second sub-period. Contrary to this, growth of both energy and materials increased between the first and the second sub-periods.

5.1 Partial Productivity Growth

Partial productivity ratios (value of output) for selected years for two factor inputs, capital and labour and two non-factor inputs energy and materials are given in Table 5.1. This table also shows changes in capital per head over time. The same information is presented in an indexed form in the even numbered figure. Partial productivity growth rates in the aggregate manufacturing industry are summarised in Table 5.1a below:

Table 5.1: Partial Productivity Ratios: Aggregate Manufacturing

Year	Capital	Labour	Energy	Materials	K/L
1973	1.82	0.34	21.20	1.60	0.18
1974	2.32	0.36	23.79	1.77	0.15
1975	2.47	0.38	22.38	1.68	0.16
1976	2.36	0.41	22.99	1.76	0.17
1977	2.21	0.43	24.34	1.80	0.19
1978	2.26	0.48	23.52	1.88	0.21
1979	2.18	0.44	21.72	1.91	0.20
1980	2.11	0.42	21.34	1.85	0.20
1981	2.28	0.48	23.74	1.91	0.21
1982	2.24	0.53	23.09	1.93	0.23
1983	2.01	0.55	20.66	1.90	0.27
1984	1.98	0.58	19.40	1.90	0.29
1985	2.10	0.66	19.29	1.77	0.31
1986	2.10	0.70	20.02	1.76	0.34
1987	2.01	0.73	18.81	1.78	0.36
1988	2.21	0.80	21.92	1.74	0.36
1989	2.29	0.86	20.24	1.68	0.37
1990	2.14	0.92	21.05	1.72	0.43
1991	2.17	0.91	20.58	1.70	0.42
1992	2.10	0.96	20.19	1.61	0.46
1993	1.99	1.02	23.03	1.64	0.51

During 1973-93, productivity of capital declined at the rate of 0.29% per annum, while that of labour increased a the rate of 5.64 % per annum. The increase in labour productivity was almost entirely due to the process of capital deepening , or the increase in the availability of capital per head which registered growth at the rate of 5.91 % per annum. Mark the parallel

movement of indices of labour productivity and capital /labour ratio for bulk of the period in the figure above. Both energy and materials recorded negative growth of productivity, though the rates were small.

There were important differences in the rates of growth between the two sub-periods. The small but positive productivity growth in the case of capital in the first period turned negative in the second. Labour productivity gained two percentage points between the first and the second periods, paralleling the rise of capital-labour ratios. Both energy and materials experienced reversal in their growth rates between the two periods going from positive to negative.

Figure 5.1: Partial Productivity Indices: Aggregate Manufacturing (based on const. 1973-74 values)

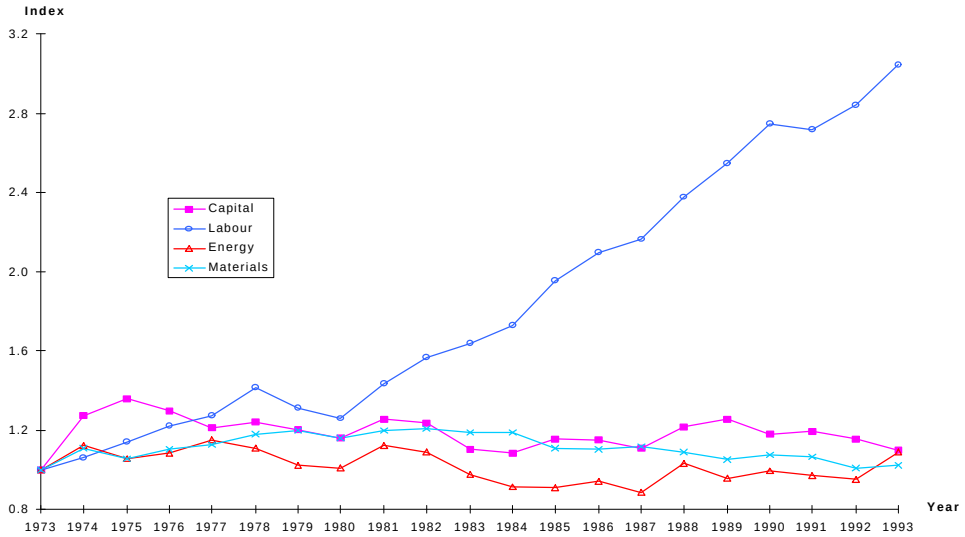


Table 5.1.a: Partial Productivity Growth (% p.a.)

	Capital	Labour	Energy	Materials	K/L
1973/75 - 80/82	0.06	4.17	0.17	1.73	3.93
1980/82 - 91/93	- 0.53	6.59	- 0.60	-1.28	7.20
1973/75 -91/93	- 0.29	5.64	- 0.30	- 0.12	5.91
Trend rate of growth					
1973-93	- 0.29	5.66	- 0.62	- 0.28	5.95
t-statistic	(- 1.15)	28.3	(-2.53)	(-1.34)	(21.79)
R-squared	0.06	0.97	0.25	0.08	0.96

5.2 Total Productivity Growth

Total productivity indices using three alternative measures are shown in Table 5.2 and illustrated in the even numbered figure below. The growth rates in terms of the three indices are summarised in Table 5.2a

Table 5.2: Total Productivity Indices: Aggregate Manufacturing

Year	Translog		Solow		Kendrick	
1973	100		100		100	
1974	113.8	(12.9)	112.9	(12.9)	113.7	(13.7)
1975	112.8	(-0.9)	111.6	(-1.1)	112.2	(-1.3)
1976	115.5	(2.4)	114.5	(2.6)	115.4	(2.9)
1977	116.2	(0.6)	115.1	(0.5)	116.4	(0.9)
1978	121.0	(4.1)	120.4	(4.6)	121.4	(4.3)
1979	119.4	(-1.3)	118.7	(-1.4)	120.0	(-1.2)
1980	115.7	(-3.2)	115.0	(-3.2)	116.2	(-3.1)
1981	122.6	(5.8)	122.3	(6.3)	123.0	(5.9)
Average						
1973-81		2.54		2.66		2.74
1982	123.4	(0.7)	123.2	(0.7)	124.1	(0.8)
1983	118.6	(-4.0)	117.8	(-4.3)	119.4	(-3.8)
1984	118.2	(-0.4)	117.3	(-0.5)	118.9	(-0.4)
1985	115.9	(-1.9)	114.6	(-2.2)	116.6	(-1.9)
1986	116.7	(0.6)	115.4	(0.7)	117.1	(0.4)
1987	116.1	(-0.5)	114.7	(-0.6)	116.5	(-0.5)
1988	119.1	(2.5)	117.8	(2.6)	119.0	(2.2)
1989	117.5	(-1.3)	115.9	(-1.6)	117.2	(-1.5)
1990	118.4	(0.8)	116.8	(0.8)	118.0	(0.6)
1991	117.6	(-0.6)	116.1	(-0.6)	117.2	(-0.6)
1992	113.2	(-3.9)	110.9	(-4.4)	112.4	(-4.1)
1993	114.6	(1.2)	112.4	(1.3)	113.5	(1.0)
Average						
1982-93		-0.47		-0.59		-0.55

Note: Figures in parentheses are year to year growth rates.

Total productivity grew at the insignificant rate 0.31 per cent per annum during 1973-93. The implication of this is that productivity growth contributed merely 3.76 percent to the growth of output, while the rest 9.6.2% was contributed by the expansion of factor inputs, with capital and energy use leading.

Again, there was divergence in growth rates of total productivity in the two sub-periods of our study. In the first period, it grew at a reasonable rate of 1.47% per annum, contributing 18 % to the growth of output. The rest 82% being contributed by input expansion. In the second sub-period, the contribution of input growth was 106% since the contribution of input growth was -6%.

Figure 5.2: Total Productivity Indices : Aggregate Manufacturing (based on const. 1973-74 values)

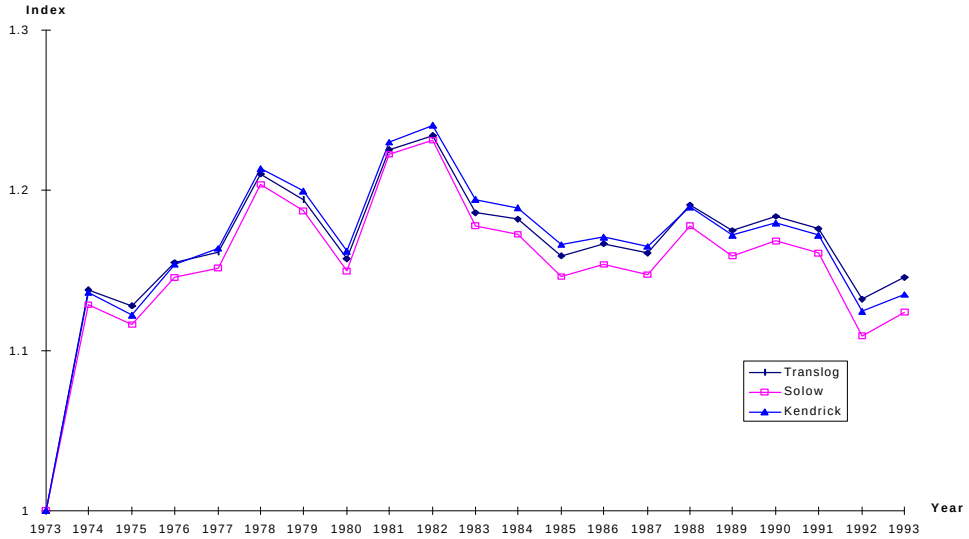


Table 5.2.a: Total Productivity Growth (% p.a.)

	Translog	Solow	Kendrick
1973/75 -80/81	1.47	1.51	1.57
1980/82 -91/93	-0.42	-0.54	-0.52
1973/75 -91/93	0.31	0.25	0.29
Trend rate 1973-93	0.20	0.14	0.18
t-statistic	(1.36)	(0.92)	(1.13)
R-square	0.08	0.04	0.06

Total productivity versus total factor productivity

Before we conclude, we present estimates of TFPG. Even though they are not the main focus of our study, we estimated them to facilitate a comparison with estimates of other researchers. Indices of total factor productivity are given in Figure 5.2.1. Total factor productivity growth is given in Table 5.2.1.

Total factor productivity grew at the rate of 1.39 per cent per annum during 1973-93. Again there was a divergence of trends between the two sub-periods. From weak negative growth it turned into a strong positive growth between the first and the second periods.

These estimates agree with those of other researchers where the same methodology and the same time frame have been used. This validates our methodology and construction of variables. Also, the contrary trends in the sub-periods in the two sets of estimates point to the problems raised regarding the findings of Balakrishnan and Pushpangdan (1994).

Figure 5.2.1: Total Factor Productivity Indices (based on const. 1973-74 values)

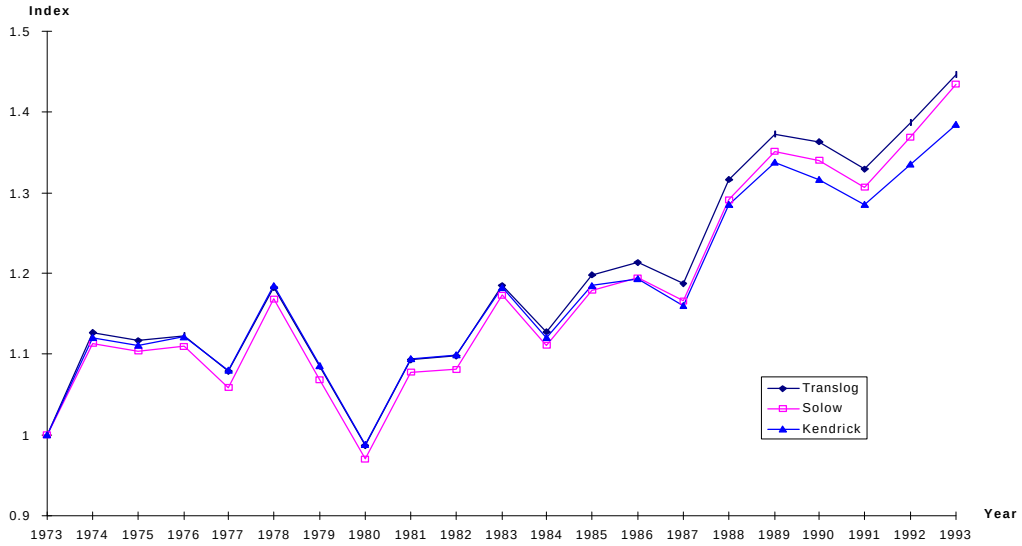


Table 5.2.1: Total Factor Productivity Growth (% p.a.)

	Translog	Solow	Kendrick
1973/75 -80/81	- 0.29	- 0.39	- 0.22
1980/82 -91/93	2.48	2.51	2.11
1973/75 -91/93	1.39	1.37	1.20
Trend rate			
1973-93	1.49	1.46	1.28
t-statistic	7.23	6.97	6.71
R-square	0.73	0.72	0.70

5.3 Policy Environment and Productivity Growth

As we suggested earlier, relating estimates of productivity growth to specific identifiable policy measures is not a straightforward task. This is particularly true at the aggregate manufacturing level.

In general, as Ahluwalia suggests, productivity growth seems to be positively related to growth of output in the industry. Therefore, a large part of explanation of what causes productivity growth will be found in what causes output growth. Factors which affect output growth can broadly be classified as those which affect it from the demand side and those which affect it from the supply side.

Specifically, for output growth in aggregate manufacturing, as Ahluwalia explains, the first half of the sixties was a period of rapid growth, particularly in heavy industries. From the mid-sixties onwards, industrial growth suffered a deceleration compared to the first half of 1960's This led to a re-orientation of policies in the seventies. The period from late 1970's onwards was characterised by domestic deregulation, a movement away from physical controls, significant

rationalisation and some liberalisation of trade policy, more investment in the infrastructure and improved productivity in the infrastructure sector.

Also, rising fiscal deficit in the 1980's created resurgent demand conditions in response to which supply could be enhanced through productivity improvements resulting from the re-orientation of the policy framework and the tuning up of the infrastructure.

Following from these, there is evidence of a significant improvement in productivity growth in the manufacturing sector in the first half of 1980's. This finding seems to be a valid explanation of estimates of total factor productivity reported by us above. The contrary movements in the total productivity growth trends and total factor productivity, in given time periods, as notices above can arise because of differential rates of growth of factor and non-factor inputs.

6. Aluminium

Aluminium industry (subgroup 335) is of strategic importance in the development of the Indian economy. The electrical sector in India is the most important consumer of aluminium products with over 50% of the offtake of total production. Apart from this sector, aluminium has wide and varied uses in transport, building and construction, consumer durables, utensils, packaging, coinage and other miscellaneous uses. Per capita consumption of aluminium in India is only 0.4 kg. In comparison, Malaysia consumes 2.4 kg, Brazil 3.3 kg, and the USA 22 kg. With the growing importance of the electric sector in India, the demand for the products of this industry is bound to rise at a rapid rate in future. The industry is small in terms of size of output and of capital in comparison with other energy intensive industries. Average levels of output and inputs for the beginning and the end of our period of study are given in Table 6.0 below.

Table 6.0: Output and Inputs: Aluminium Industry

Average	Output	Capital	Labour	Energy	Materials	No of factories
1973-75	12494	14461	19847	1946	7346	167
1991-93	42222	53896	34384	10913	24162	369

Notes:
Figures are in const. lakhs of Rupees (1973-74 values), except labour and factories which are numbers.
Figures are averages for three years at the beginning and end of the period of study.

The industry's output of Rs. 0.42 bn. during 1991-93 accounted for only 0.5 per cent of the output in the manufacturing sector. Its share of capital stock was only 1.3% of that in the aggregate manufacturing. It was the smallest employer with only 0.4 per cent of the total labour force in manufacturing. The industry is highly energy intensive. It accounted for 2.8% of total energy consumption. The share of energy costs in the value of output was 26%, the highest among the six and 66% higher than the figure period 1973-75.

The indices of output and inputs for the years 1973-93 are shown in Figure 6.0 below, and their growth rates are shown in Table 6.0a.

Figure 6.0: Real Output and Input Indices: Aluminium

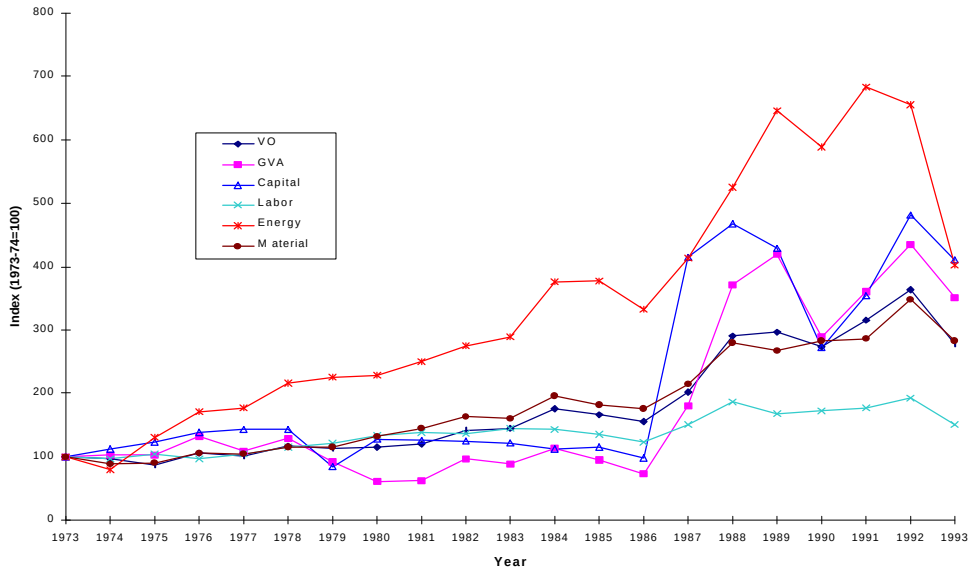


Table 6.0.a: Growth of Output and Inputs : Aluminium

Year	Output	Capital	Labour	Energy	Materials
1973/75 - 80/82	4.08	1.70	4.53	13.47	6.70
1980/82 - 91/93	8.90	11.49	2.20	7.93	6.92
1973/75 - 91/93	6.99	7.58	3.10	10.05	6.83

Note: Figures are compound annual growth rates between the three year periods for which average values for the relevant parameters were taken.

During the years 1973-93 output grew at the rate of 7 per cent per annum. This rate was marginally lower for the output in aggregate manufacturing. It was also the lowest among the six industries. The growth of output was accompanied by a 7.6 per cent per annum growth in the stock of gross fixed capital. Mark the sudden increase in size of capital stock in 1986, and the consequent acceleration in its growth rate in the second sub-period above. The labour force grew at the rate of 3.1 per cent per annum. The consumption of energy at 10.1 per cent per annum exceeded that of other inputs. Finally, material inputs grew at the rates of 6.8 per cent per annum. The growth rate of energy consumption was the highest among the six except for the paper industry. At a value of 1.4 this was true for the implied elasticity of energy consumption with respect to output too.

6.1 Partial Productivity Growth

Partial productivity ratios for value of output and two factor inputs, capital and labour and two non-factor inputs, energy and materials are given in Table 6.1. This table also shows changes in capital per head over time. The same information is presented in an indexed form in the even numbered figure. For highlighting important trends the information on partial productivity growth in the aluminium industry is summarised in Table 6.1a below:

There was little growth of productivity of capital during 1973-93. In fact it registered a small decline of 0.56 per cent per annum. Labour productivity increased during this period at the annual rate of 3.8 per cent. This could partly be explained by a 4.4 per cent per annum growth rate of capital intensity. There appears to be substitution of labour by capital. Going back to Table 6.0a, one can see that as output growth picked up between the first and the second sub-periods, the rate of growth of capital increased almost ten times, while that of labour declined to half. A possible explanation is that after 1986, when new capacity came on stream, it was of the type which used less labour but more energy per unit of capital.

Productivity of energy declined with energy requirement per unit of output, on an average, being higher by 66 % at the end of the period compared to that at the beginning, indicating a decline in productivity approximately at the rate of 2.9 per cent per annum. There was an insignificant, 0.14% per annum, increase in the productivity of material use.

As Figure 6.1 shows, there were wide fluctuations in productivity ratios over the years and there were divergent movements in them in the two sub-periods. In the case of capital, a positive growth of capital productivity in 1973-81 was reversed by stronger negative growth during 1981-91. The reverse was true for labour, energy and material inputs. A sudden increase in the size of fixed capital in the year 1986 was not matched immediately with a corresponding increase in output. It pushed up the K/L ratio dramatically and therefore affected post 1981 growth rates.

Table 6.1: Partial Productivity Ratios : Aluminium

Year	Capital	Labour	Energy	Materials	K/L
1973	1.02	0.67	7.05	1.67	0.65
1974	0.88	0.66	8.50	1.83	0.75
1975	0.72	0.56	4.68	1.60	0.78
1976	0.78	0.73	4.33	1.67	0.93
1977	0.72	0.65	4.00	1.63	0.90
1978	0.83	0.67	3.79	1.68	0.81
1979	1.38	0.63	3.54	1.66	0.45
1980	0.91	0.57	3.54	1.46	0.62
1981	0.97	0.58	3.35	1.38	0.59
1982	1.16	0.69	3.62	1.44	0.59
1983	1.22	0.67	3.52	1.51	0.55
1984	1.60	0.82	3.28	1.50	0.51
1985	1.47	0.82	3.11	1.53	0.56
1986	1.63	0.85	3.30	1.48	0.52
1987	0.50	0.90	3.45	1.58	1.80
1988	0.63	1.04	3.90	1.74	1.64
1989	0.71	1.17	3.23	1.85	1.66
1990	1.02	1.05	3.27	1.62	1.03
1991	0.91	1.19	3.25	1.85	1.31
1992	0.77	1.26	3.91	1.75	1.64
1993	0.69	1.23	4.85	1.64	1.78

Figure 6.1: Partial Productivity Indices: Aluminium (based on const. 1973-74 values)

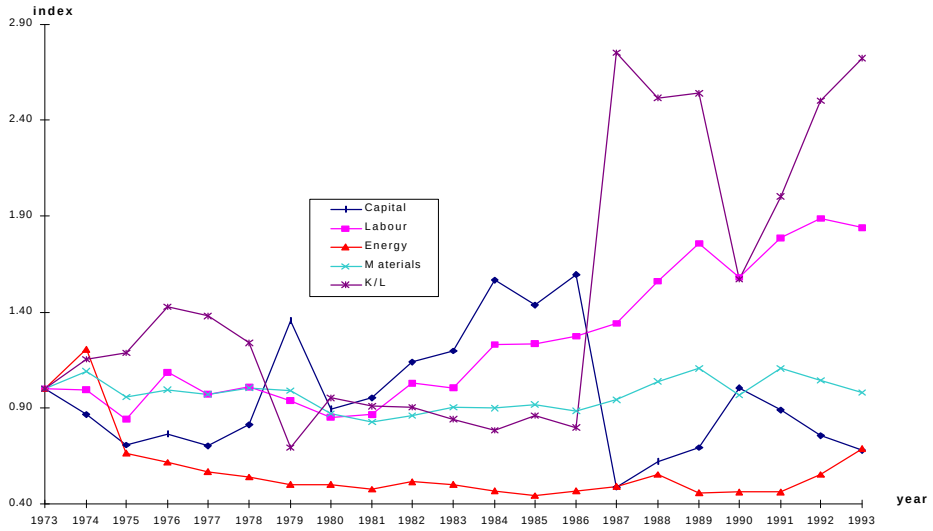


Table 6.1.a: Partial Productivity Growth :Aluminium(% p.a.)

	Capital	Labour	Energy	Materials	K/L
CAGR					
1973-82	2.18	-0.47	-8.93	-2.48	-2.70
1982-93	-2.27	6.55	1.22	1.85	9.15
1973-93	-0.56	3.77	-2.85	0.14	4.38
Trend rate					
1973-93	-0.52	3.86	-2.25	0.18	4.39
	(-0.44)	(8.21)	(-2.81)	(0.58)	(3.13)
R-Square	0.01	0.78	0.29	0.02	0.34

Note: Figures in parentheses are t-values

6.2 Total Productivity Growth

Total productivity indices in terms of three alternative measures are shown in Table 6.2 and illustrated in even numbered figure. Further, the growth experience is summarised in Table 6.2.a.

Mirroring the growth of output and of partial productivity indices, there was little growth of total productivity as suggested by cagr of 0.1 per cent per annum. Thus productivity growth contributed only 1.43 per cent to growth of output. The rest 98.57 per cent being contributed by the expansion of inputs, mainly energy and capital.

This low overall growth rate was the result divergent trends in growth in the two sub-periods. The negative growth rate of the first sub-period is a continuation of trends which Ahluwalia noticed in the case of non-ferrous metals, which she termed as the worst performers in terms of productivity growth.

Table 6.2 Total Productivity Indices: Aluminium

Year	Translog		Solow		Kendrick	
1973	1		1		1	
1974	1.06	(5.79)	1.05	(4.85)	1.05	(4.95)
1975	0.85	(-22.48)	0.80	(-23.28)	0.84	(-20.32)
1976	0.88	(4.24)	0.84	(4.88)	0.87	(4.60)
1977	0.84	(-5.51)	0.80	(-5.52)	0.83	(-5.49)
1978	0.87	(3.93)	0.83	(4.16)	0.85	(3.42)
1979	0.93	(7.04)	0.88	(6.15)	0.89	(4.03)
1980	0.82	(-13.08)	0.74	(-16.21)	0.78	(-12.06)
1981	0.79	(-3.59)	0.71	(-3.82)	0.76	(-2.89)
Average 1973-81		-2.96		-3.60		-2.97
1982	0.85	(7.69)	0.77	(8.42)	0.82	(8.46)
1983	0.87	(1.84)	0.78	(1.91)	0.84	(1.96)
1984	0.89	(2.08)	0.80	(1.70)	0.86	(2.48)
1985	0.87	(-1.57)	0.79	(-1.56)	0.85	(-1.22)
1986	0.89	(1.42)	0.80	(1.31)	0.86	(1.14)
1987	0.79	(-11.27)	0.63	(-20.61)	0.74	(-13.60)
1988	0.91	(14.17)	0.75	(18.01)	0.86	(15.46)
1989	0.93	(2.23)	0.76	(1.50)	0.86	(0.81)
1990	0.97	(4.34)	0.78	(3.70)	0.86	(-0.13)
1991	1.01	(3.49)	0.82	(3.95)	0.91	(5.39)
1992	0.98	(-2.30)	0.79	(-3.12)	0.91	(-0.29)
1993	0.97	(-1.65)	0.78	(-1.42)	0.90	(-0.71)
Average 1982-93		1.70		1.15		1.65

Note: Figures in parentheses are year to year growth rates.

Figure 6.2: Total Productivity Indices (based on const. 1973-74 values)

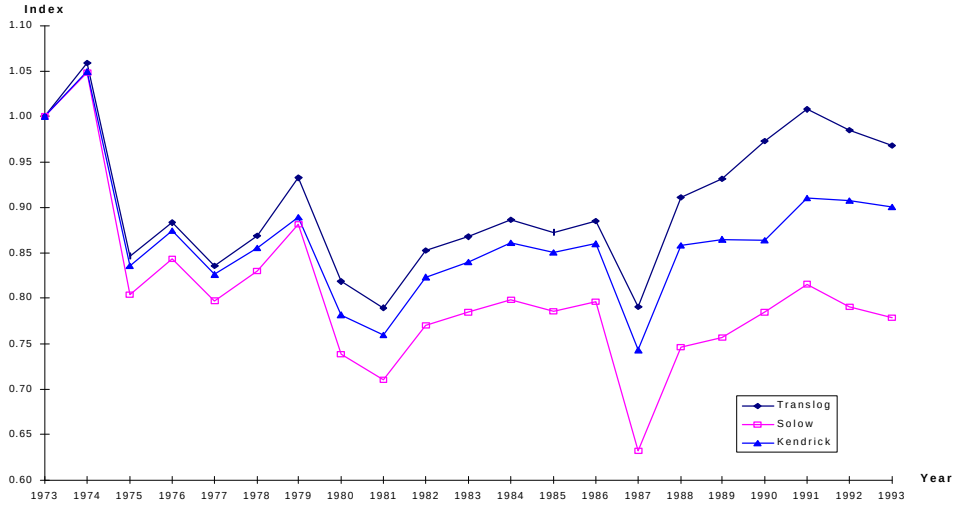


Table 6.2.a: Total Productivity Growth: Aluminium

	Translog	Solow	Kendrick
CAGR			
1973-81	-1.91	-2.85	-2.42
1981-93	1.67	0.52	1.16
1973-93	0.10	-0.99	-0.33
Trend rate			
1973-93	0.24	-0.93	-0.21
t-statistic	(0.79)	(2.83)	(0.73)
R-Square	0.03	0.30	0.03

6.3 Policy Environment and Productivity Growth

The Industries (Development and Regulation) Act, 1951 placed non-ferrous metals (which include aluminium) under the purview of licensing both in respect of creating new capacity, or effecting substantial expansion. Industrial Policy resolution of 1956 put aluminium in the category where industries will be progressively state owned and in which the state will generally take the initiative in establishing new undertakings, but in which private enterprise will also be expected to supplement the efforts of the state.

The industry has been subject to strict state controls. State itself has a big share in the production capacity. With the commissioning of NALCO in 1986, the share of public sector in aluminium smelting became more than half of total installed capacity. Thus public sector came to have a decisive influence. Role and significance of the government in the functioning of the aluminium industry encompasses licensing, price controls, supplies of essential inputs, fiscal levies and finally the state is a big consumer.

Being an essential input for the development of the power sector, the industry is under a statutory obligation to produce enough electric grade aluminium, which is subject to price controls. The system of administered pricing of the primary metal failed to cope with the rising production costs. Also, the major inputs going into the making of aluminium, power, petroleum, coke and pitch are supplied by the public sector. Lower profitability on the EC grade aluminium forces companies to increase the prices of other commodities which are not statutorily regulated.

Aluminium industry is crucial to the development of power sector. Paradoxically, the smelting of aluminium requires very large amounts of electric power. Lack of adequate and uninterrupted power supply has led to poor utilisation of capacity. This has been a major source of slow growth of productivity. If we compare year to year growth rates of capacity utilisation with those of productivity of capital and of total productivity, the two seem to be strongly related. This seemed to be true for the brief period 1981-1986 for which capacity utilisation data were available.

The situation with respect to size and scale economies is ambiguous. The number of units increased from 167 to 369, with the size of the firms in terms of average capital increasing from 86.4 lakhs to 145.4 lakhs, an increase of 52%. The scale of output increased from 74.68 to 114.32 lakhs, implying an increase of 53%.

There were no significant changes in the energy using technology. Energy utilisation per unit of capital, as reflected in the E/K ratio went up from 0.13 in 1973/75 to 0.29 in 1981/83, an increase of 123%. It declined to 0.21 at the end of the period, but was still higher by 61% compared to the base year figure.

7. Cement

Cement industry (subgroup 324) belongs to the core sector of the economy. Average level of output and inputs for two periods are given in Table 7.0 below.

Table 7.0: Output and Inputs: Cement Industry

	Output	Capital	Labour	Energy	Materials	No of factories
1973-75	26267	14005	16894	5284	13141	224
1991-93	146466	111693	101443	30795	49250	832

Notes:
Figures are in const. lakhs of Rupees (1973-74 values), except labour and factories which are numbers.
Figures are averages for three years at the beginning and end of the period of study.

The industry produced an average output worth Rs. 1.46 bn during the years 1991 to 93. This was approximately 1.75% of the output (and of 2.2% of the GVA) of the manufacturing sector as a whole, and made it the third largest in terms of size of output among the six energy intensive industries. It accounted for 2.8% of the fixed capital and employed 1.2% of the labour force in the manufacturing sector. With a 7.83% share in total manufacturing, its consumption of energy was the second highest among the six industries. This was true of its ranking in terms of energy intensity of output too. Energy cost on average were 21% of the value of output during 1991-93. This was 4.5% higher than the average for the years 1973-75.

The indices of value of output and inputs in the cement industry during 1973-93 are illustrated in Figure 7.0 below. Their growth rates are shown in Table 7.0a.

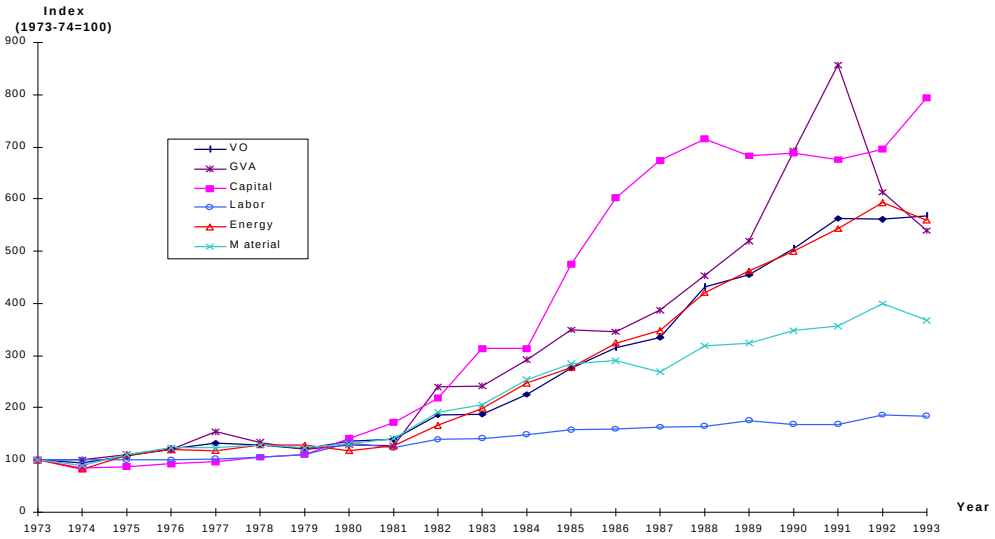
Table 7.0.a: Growth of Output and Inputs: Cement

Year	Output	Capital	Labour	Energy	Materials
1973/75 - 80/82	6.22	10.15	4.07	5.06	6.41
1980/82 - 91/93	12.51	13.57	2.85	13.75	8.39
1973/75 - 91/93	10.02	12.23	3.32	10.29	7.62

Note: Figures are compound annual growth rates between the three year periods for which average values for the relevant parameters were taken.

Output during the years 1973-93 grew at the rate of 10 % per annum. This was accompanied by a 12.2 % growth in the stock of gross fixed capital and a 3.3% growth in the labour force. Consumption of energy and material inputs grew at rates of 10.3 % and 7.6% per annum respectively. The implied elasticity of energy consumption with respect to output was 1.03 compared to 1.04 in the aggregate manufacturing.

Figure 7.0: Real Output and Input Indices: Cement



7.1 Partial Productivity Growth

Partial productivity ratios for two factor inputs, capital and labour and two non-factor inputs, energy and materials are given in Table 7.1. This table also shows changes in capital per head over time. The same information is presented in an indexed form in the even numbered figure. For highlighting important trends the information on partial productivity growth in the cement industry is summarised in Table 7.1a below:

During 1973-93, productivity of capital declined at the rate of 1.97% per annum, while that of labour increased a the rate of 6.5 % per annum. The increase in labour productivity was to an extent the result of the process of capital deepening , or the increase in the availability of capital per head which registered growth at the rate of 8.6 % per annum. The productivity of energy declined at the rate of 0.28 % per annum, indicating a moderately increasing energy intensity in the production of cement. Productivity of material use increased at the rate of 2.23 percent per annum.

The overall change in productivity of different inputs conceals important changes within the period. As the figure above indicated, there was either a decline or stagnation in the productivity of different inputs till 1981. After that date, there was a reversal in many of the trends. The rate of decline of productivity of capital got moderated having increased from -3.53% to -0.96 % per annum. Labour productivity got a big boost jumping from 2.02 % to 9.44% per annum. This was directly related to an acceleration in the rate of capital deepening, the growth rate of capital per head having almost doubled between the first and the second periods. This was the direct result of a massive inflow of investment in the cement industry to be discussed below. Energy requirements per unit of output which were declining in the first period reversed their trend indicating a decline in energy productivity. Opposite was the case for materials where there was a remarkable increase in the efficiency of use.

Table 7.1: Partial Productivity Ratios

Year	Capital	Labour	Energy	Materials	K/L
1973	1.68	0.46	4.76	1.97	0.28
1974	1.90	0.44	5.51	2.11	0.23
1975	2.08	0.50	4.75	1.93	0.24
1976	2.18	0.56	4.81	1.94	0.26
1977	2.29	0.59	5.36	2.10	0.26
1978	2.06	0.56	4.76	1.98	0.27
1979	1.84	0.51	4.49	1.94	0.28
1980	1.61	0.47	5.51	2.07	0.29
1981	1.36	0.52	5.25	1.96	0.38
1982	1.42	0.62	5.35	1.92	0.43
1983	1.01	0.62	4.53	1.81	0.61
1984	1.21	0.70	4.36	1.76	0.58
1985	0.98	0.81	4.72	1.91	0.83
1986	0.88	0.92	4.65	2.15	1.04
1987	0.83	0.95	4.60	2.46	1.14
1988	1.01	1.21	4.89	2.68	1.19
1989	1.12	1.20	4.70	2.77	1.07
1990	1.23	1.39	4.81	2.87	1.13
1991	1.40	1.54	4.94	3.12	1.10
1992	1.35	1.38	4.50	2.77	1.02
1993	1.20	1.42	4.84	3.05	1.18

Figure 7.1: Partial Productivity Indices (based on const. 1973-74 values)

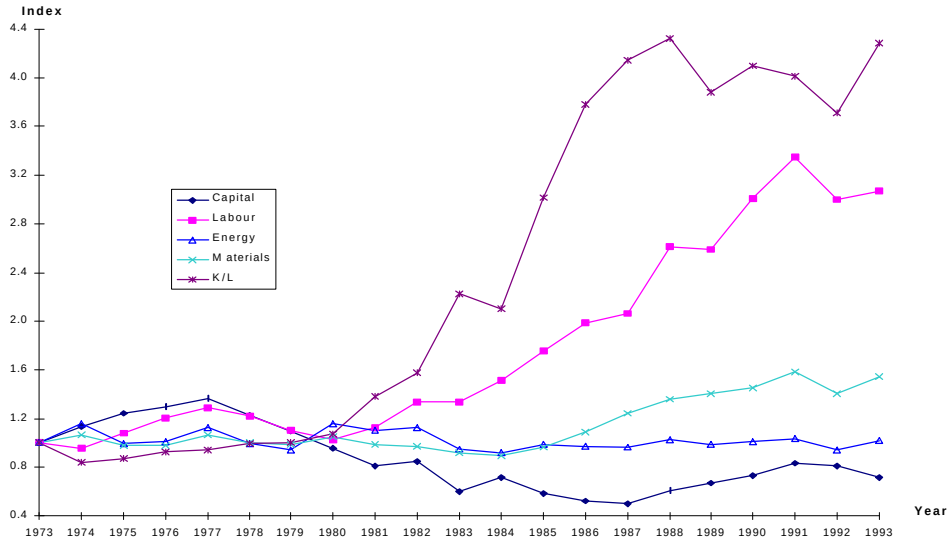


Table 7.1.a: Partial Productivity Growth (% p.a.)

	Capital	Labour	Energy	Materials	K/L
1973/75 – 80/82	-3.53	2.02	1.00	-0.16	5.81
1980/82 – 91/93	-0.97	9.44	-1.09	3.78	10.45
1973/75 –91/93	-1.97	6.49	-0.28	2.23	8.62
Trend rate of growth	Capital	Labour	Energy	Materials	K/L
1973-93	-3.53	6.56	-0.37	2.27	10.09
t-statistic	-4.41	12.43	-1.54	5.19	12.87
R-squared	0.51	0.89	0.11	0.59	0.89

7.2 Total Productivity Growth

Three alternative measures of total productivity are given in Table 7.2 and shown in the accompanying figure. The growth experience is summarised in Table 7.2a.

Table 7.2: Total Productivity Indices: Cement

Year	Translog		Solow		Kendrick	
1973	1		1		1	
1974	1.09	(8.17)	1.07	(7.22)	1.09	(8.54)
1975	1.04	(-3.89)	1.02	(-4.80)	1.04	(-4.29)
1976	1.07	(2.50)	1.05	(2.73)	1.06	(2.34)
1977	1.16	(7.77)	1.14	(8.25)	1.15	(8.30)
1978	1.07	(-8.23)	1.04	(-8.44)	1.06	(-7.60)
1979	1.00	(-5.85)	0.98	(-5.80)	1.01	(-5.27)
1980	1.05	(4.15)	1.02	(3.72)	1.05	(4.08)
1981	0.98	(-6.54)	0.94	-7.16)	0.98	(-6.35)
Average 1973-81		-0.24		-0.53		-0.03
1982	1.00	(2.13)	0.97	(2.55)	1.00	(2.04)
1983	0.85	(-16.82)	0.78	(-19.67)	0.86	(-13.99)
1984	0.88	(4.30)	0.81	(4.56)	0.89	(3.70)
1985	0.88	(-0.45)	0.80	(-1.75)	0.90	(0.29)
1986	0.90	(1.83)	0.81	(1.39)	0.91	(1.72)
1987	0.93	(3.34)	0.84	(3.41)	0.94	(3.06)
1988	1.04	(11.85)	0.96	(14.34)	1.07	(13.79)
1989	1.07	(2.57)	0.98	(2.41)	1.11	(3.69)
1990	1.13	(5.75)	1.04	(5.98)	1.17	(5.95)
1991	1.23	(8.52)	1.13	(8.90)	1.28	(8.77)
1992	1.14	(-8.17)	1.04	(-8.16)	1.17	(-8.25)
1993	1.17	(2.48)	1.06	(1.77)	1.20	(1.96)
Average 1982-93		1.44		1.31		1.89

Note: Figures in parentheses are year to year growth rates.

Figure 7.2: Total Productivity Indices (based on const. 1973-74 values)

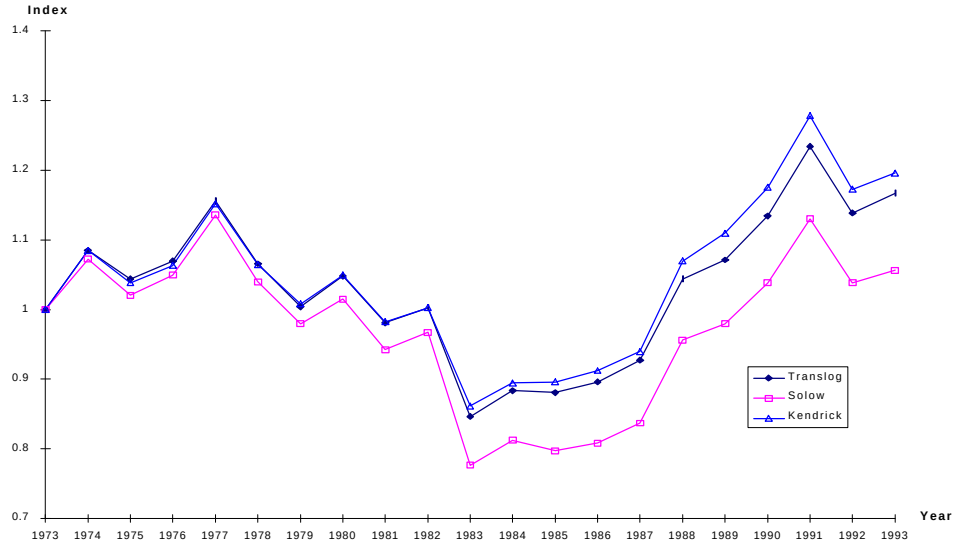


Table 7.2.a: Total Productivity Growth (% p.a.)

	Translog	Solow	Kendrick
1973/75 -80/82	- 0.46	- 0.79	- 0.42
1980/82 -91/93	1.42	0.89	1.69
1973/75 -91/93	0.69	0.23	0.86
Trend rate	Translog	Solow	Kendrick
1973-93	0.26	- 0.28	0.47
t-statistic	0.70	-0.67	1.25
R-square	0.03	0.02	0.08

Total productivity experienced slow growth with an overall rate of 0.69 per cent per annum. Thus for the period as a whole, the contribution of productivity growth to output growth was only 6.9%. The rest 93.1% having been made possible by expansion of factor and non-factor inputs, and mainly by a sizeable growth of capital.

Like in the case of partial productivity growth, there was reversal of trends in the two sub-periods of our study, whereby a weak negative growth in the first period of -0.46 % per annum was turned into positive growth of 1.42 per cent per annum.

7.3 Policy Environment and Productivity Growth

Productivity and output growth in the cement industry is directly linked to liberalisation trends in the economy. In fact, it is one of those industries where the experiment in liberalisation was put into concrete practice even before economic liberalisation was adopted as policy in the Indian economy.

The cement industry was placed under government control during the second world war. Even after the war, the controls were continued in one form or the other. As Bhanu[5] notes, the control was total and every tonne of cement produced was deemed to have been acquired by the government at a statutorily notified price and thereafter distributed on the basis of release permits issued by authorities. Production and additions to capacity were controlled through licenses which were required for new units as well as for expansion in the existing units.

With its income elasticity at 1.14, demand was never a problem. It always exceeded supply. The slow growth of output was largely the result of restricted investment. Prior to de-regulation, the price realised by the producers did not reflect the true demand. The implied discounted rate of return was poorer in cement industry as compared to corresponding rates in other industries. Depressed profitability made the investors shy away from the cement industry. As the domestic production could not meet demand and as imports were restricted due to foreign exchange shortage, black markets emerged.

In 1982, the industry was partially decontrolled. Control on price and distribution as well as the licensing of new cement units were relaxed. While cement firms were free to sell 33.3% of (non-levy) output on the free market at a price determined by supply and demand, the other 66.7% was governed by the administered price fixed by the government from time to time. From 1989, both price and distribution controls in the cement industry were fully relaxed.

Following the decontrol, there was a rapid expansion of output in the industry, which showed up ultimately in the rate of growth doubling from 6.2% p.a. in the first period of our study to 12.5% in the second. This was made possible by significant additions to capacity as investment flowed in to take advantage of a huge market.

The higher growth of output made possible higher productivity growth because of economies of size and scale and better utilisation of capacity, the factors which were mentioned by us in section above. As the number of units in the industry went up from 224 in the beginning of the period to 832 towards the end, the size of units, measured by average size of fixed capital increased from 62.5 lakhs to 134.25 lakhs, an increase of 114%. Similarly, the scale of operations, measured by average size of the output went from 117 lakhs to 176 lakhs, an increase of 50%.

Along with these changes in size and scale, there was a qualitative energy saving change in the composition of capital. This is reflected in a decline in the energy used per unit of capital or E/K ratio which can be read from Table 7.0. Therefore, on average each unit of capital was using 27% less energy at the end of the period than at the beginning.

More importantly, as Gokarn and Vaidya[6] note, the new capacity which was created after decontrol was by way of plants that were on the average substantially larger than the existing plants, and all the new capacity that was created used the dry process, which is technologically

[5] Bhanu, V. (1995), "Liberalisation and Performance of Cement Industry", *Economic and Political Weekly*, 26 August, M111-M116.
[6] Gokarn, S. and R. Vaidya (1993), " … Cement Industry", *Economic and Political Weekly*,

superior to the wet process. The dry process consumes 43 to 50 % less heat, and 8 to 10 % less electricity than the wet process. There is a significant difference in the kiln productivity: dry process being 2.5 to 3 times more productive than the wet process. It implies that a dry process plant can install a kiln that is one-third to two-fifths the size of the kiln in a wet process plant of equal capacity, thus saving on capital costs. After de-control, no new capacity with the wet process was created. Between, 1982 and 1993, the share of capacity using dry process went up from 45% to 73%. The implication of this shift was that the industry as a whole became a more efficient producer of cement.

8. Fertilisers

Fertiliser industry (subgroups 301/311) has played a critical role in the growth of the agriculture in the country. This is a relatively large industry among the six energy intensive industries. Average levels of output and inputs for the beginning and the end of our period of study are given in Table 8.0 below.

Table 8.0: Output and Inputs: Fertiliser Industry

Average	Output	Capital	Labour	Energy	Materials	No of factories
1973-75	44820	62762	55350	4597	27833	341
1991-93	367443	158295	92249	24254	166337	598

Notes:
Figures are in const. lakhs of Rupees (1973-74 values), except labour and factories which are numbers.
Figures are averages for three years at the beginning and end of the period of study.

The industry produced on an average output worth Rs. 3.67 bn during 1991-93. This was approximately 4.4% of output produced in the manufacturing sector, and placed it second only to iron and steel in terms of size of output . With a 3.9% share this was true in terms of size of capital stock too. The industry employed 1.1% of the total labour force and accounted for 6.2% of total energy consumed, and 3.6% of the total materials consumed in the manufacturing sector. Energy costs constituted 6.6% of the value of output and represented a 5% reduction compared to the figure at the beginning of the period.

The indices of output and inputs in the fertiliser industry during 1973-93 are shown in Figure 8.0, below and their growth rates in Table 8.0a.

Table 8.0.a: Growth of Output and Inputs : Fertiliser

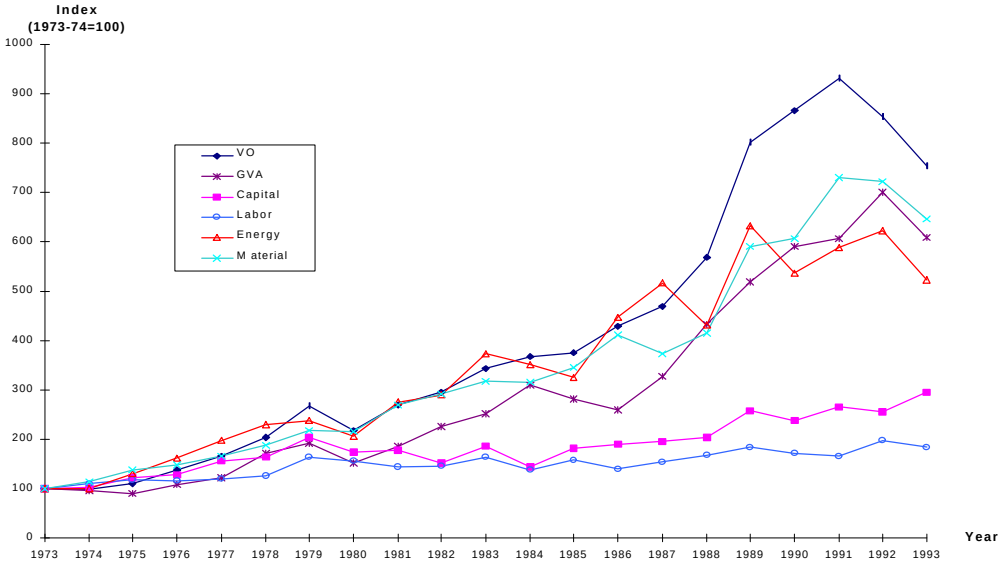
Year	Output	Capital	Labour	Energy	Materials
1973/75 - 80/82	14.25	6.53	4.44	12.94	11.99
1980/82 - 91/93	11.31	4.48	1.89	7.65	9.47
1973/75 - 91/93	12.46	5.27	2.87	9.68	10.44

Note: Figures are compound annual growth rates between the three year periods for which average values for the relevant parameters were taken.

During the years 1973-93, output grew at the rate of 12.5% per annum. With this rate of growth of output (and 11.2% of GVA) it was the fastest growing industry among the six under study. The growth of output was the result of an increase in the stock of fixed capital and of

labour force at the rates of 5.3% and 2.9% per annum respectively. The consumption of energy and materials increased at the rates of 9.7% and 10.4% per annum respectively. The implied elasticity of energy consumption with respect to output at 0.78, was lowest amongst the six except for glass industry.

Figure 8.0: Output and Input Indices : Fertilisers (based on const. 1973-74 values)



8.1 Partial Productivity Growth

Partial productivity ratios for two factor inputs, capital and labour and two non-factor inputs, energy and materials are given in Table 8.1. This table also shows changes in capital per head over time. The same information is presented in an indexed form in the even numbered figure. For highlighting important trends the information on partial productivity growth in the fertiliser industry is summarised in Table 8.1a below:

Parallel with the overall expansion noted above, fertiliser industry was characterised with growth in productivity of all inputs throughout the period. There was a significant increase in productivity of capital and labour as indicated by growth rates of 6.8 and 9.3% per annum respectively. The increase in labour productivity was the result of availability of capital per head which increased at the rate of 2.4% per annum. This capital deepening in the fertiliser sector was followed by larger use of energy per head which increased at the rate of 6.8% per annum. There was a significant increase in the productivity of energy and materials, the two having registered growth rates of 2.57% and 1.76% respectively. The two rates though modest in comparison with those of capital and labour none the less were significant when compared with growth rates of other sectors and of aggregate manufacturing.

Unlike in other sectors, and in aggregate manufacturing, there was positive partial productivity in both sub-periods of our study. As table 8.1a shows, growth of productivity of capital and labour and energy accelerated between the first and the second period, while growth

of material use showed deceleration. These developments should be understood in the background of growth of capital/labour ratio accelerating between the two periods.

Table 8.1: Partial Productivity Ratios: Fertilisers

Year	Capital	Labour	Energy	Materials	K/L
1973	0.75	0.86	10.33	1.83	1.15
1974	0.72	0.77	10.26	1.59	1.06
1975	0.67	0.79	8.73	1.44	1.19
1976	0.81	1.02	8.77	1.71	1.26
1977	0.79	1.19	8.64	1.83	1.50
1978	0.93	1.39	9.23	1.99	1.50
1979	0.98	1.39	11.63	2.24	1.42
1980	0.93	1.19	10.91	1.83	1.28
1981	1.13	1.62	10.09	1.82	1.43
1982	1.45	1.74	10.58	1.86	1.20
1983	1.38	1.79	9.51	1.98	1.30
1984	1.90	2.29	10.79	2.12	1.21
1985	1.54	2.03	11.93	1.98	1.32
1986	1.69	2.64	9.91	1.91	1.56
1987	1.79	2.61	9.36	2.29	1.45
1988	2.07	2.91	13.62	2.50	1.40
1989	2.32	3.72	13.09	2.48	1.60
1990	2.73	4.33	16.66	2.60	1.59
1991	2.62	4.85	16.38	2.33	1.85
1992	2.49	3.69	14.18	2.16	1.48
1993	1.91	3.52	14.93	2.13	1.85

Figure 8.1: Partial Productivity Indices: Fertilisers (based on const. 1973-74 values)

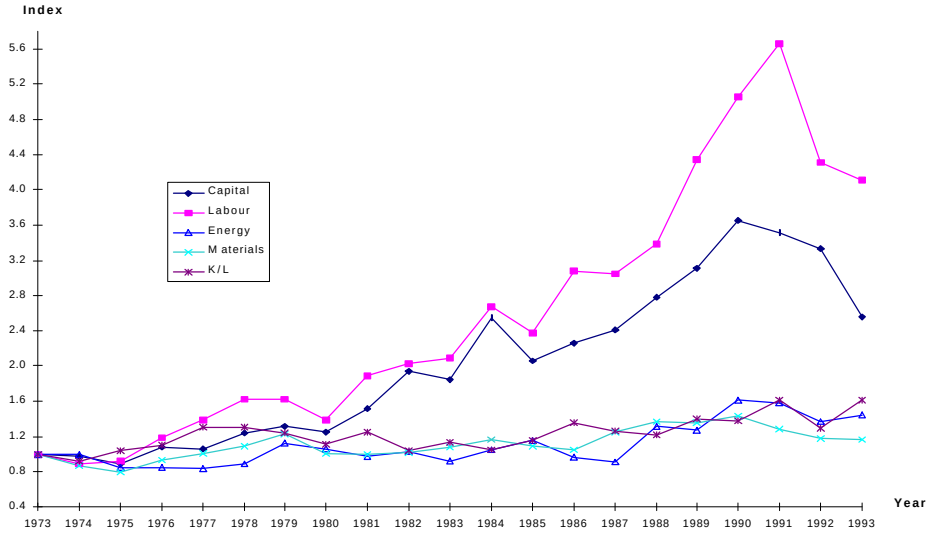


Table 8.1.a: Partial Productivity Growth:Fertilisers (% p.a.)

	Capital	Labour	Energy	Materials	K/L
CAGR*					
1973/75-80/82	7.35	9.45	1.07	1.83	2.03
1980/82-91/93	6.50	9.27	3.37	1.67	2.59
1973/75-91/93	6.83	9.34	2.46	1.73	2.37
Trend rates					
1973-93	7.21	8.97	2.57	1.89	1.76
t-statistic	(14.4)	(18.5)	(5.38)	(5.35)	(4.80)
R-Square	0.92	0.95	0.6	0.6	0.6

8.2 Total Productivity Growth

Total productivity indices in terms of three alternative indices are shown in Table 8.2 and illustrated in even numbered figure. Further, the growth experience is summarised in Table 8.2a.

Table 8.2: Total Productivity Indices: Fertilisers

Year	Translog		Solow		Kendrick	
1973	1		1		1	
1974	0.91	(-9.32)	0.90	(-9.92)	0.91	(-9.13)
1975	0.83	(-8.97)	0.81	(-10.45)	0.83	(-8.55)
1976	0.98	(16.21)	0.96	(18.86)	0.98	(17.80)
1977	1.02	(4.07)	1.00	(4.66)	1.02	(4.37)
1978	1.13	(10.54)	1.13	(12.19)	1.13	(10.97)
1979	1.26	(10.69)	1.27	(13.04)	1.26	(11.26)
1980	1.10	(-13.89)	1.12	(-12.31)	1.09	(-13.54)
1981	1.17	(5.95)	1.19	(6.66)	1.15	(5.06)
Average 1973-81		1.91		2.84		(2.28)
1982	1.28	(9.53)	1.30	(9.23)	1.23	(7.18)
1983	1.29	(0.38)	1.30	(0.05)	1.25	(1.92)
1984	1.50	(15.29)	1.49	(14.41)	1.42	(13.81)
1985	1.38	(-8.20)	1.35	(-9.47)	1.32	(-7.13)
1986	1.36	(-1.86)	1.32	(-2.17)	1.29	(-2.28)
1987	1.50	(10.24)	1.46	(10.58)	1.46	(13.10)
1988	1.75	(15.18)	1.70	(16.97)	1.67	(14.53)
1989	1.80	(3.05)	1.78	(4.18)	1.70	(1.67)
1990	2.01	(11.12)	1.98	(11.26)	1.87	(9.59)
1991	1.88	(-6.96)	1.82	(-7.79)	1.71	(-8.10)
1992	1.72	(-8.81)	1.67	(-8.54)	1.57	(-8.33)
1993	1.59	(-8.07)	1.53	(-8.06)	1.50	(-4.47)
Average 1982-93		2.57		2.55		2.62

Note: Figures in parentheses are year to year growth rates.

Figure 8.2: Total Productivity Indices: Fertilisers (based on const. 1973-74 values)

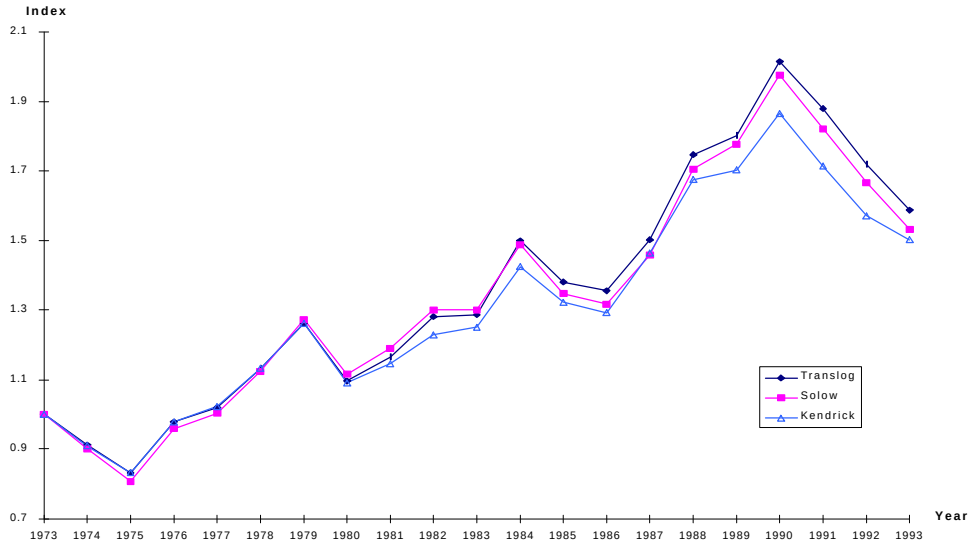


Table 8.2.a: Total Productivity Growth: Fertilisers

	Translog	Solow	Kendrick
CGAR			
1973-82	3.73	4.18	3.41
1982-93	3.52	3.05	2.98
1973-93	3.59	3.49	3.15
Trend rate			
1973-93	3.8	3.7	3.4
	(11.5)	(10.4)	(3.4)
R-square	0.87	0.85	0.85

Note: Figures in parentheses are t-statistic

Parallel with the growth of partial productivity, total productivity showed impressive increase with a trend rate of growth of 3.6% per annum. All three indices broadly showed similar movement on time and also more or less similar growth rates. Further, there was positive growth of total productivity in both sub-periods of our study. All three indices showed acceleration of growth rate in the second period.

8.3 Policy Environment and Productivity Growth

Productivity growth in the fertiliser industry during the years 1973-93 can be explained in terms of the following set of inter-related factors and policies which had a bearing on output growth. The factors relate both to the demand side and the supply side of output growth.

First, on the demand side, government actively promoted the consumption of fertilisers. It spread the awareness about the benefits of its use through extension networks, and also ensured its availability at reasonable prices. With the result, there was a strong growth of demand for fertilisers during the period of our study. After poor growth in 1972-73 and 1973-74 and a substantial decline in the year 1974-75, fertiliser consumption recovered remarkably and remained

strong during the following years. Assured demand was a major factor in encouraging firms to step up utilisation of existing capacity and also in setting up of new capacity.

Second, on the supply side, government actively aided in the growth of industry. At the general level, fertiliser industry was a major beneficiary of changes in industrial policy in India which took place in steps in 1973, 1977 and 1980. These changes led to progressive liberalisation of policies relating to licensing, foreign collaborations, and upper limits on capacity expansion. More specifically for the fertiliser industry, government assured a minimum post tax return of 12% on invested capital through Retention Price Scheme. Under this scheme, prices for each producing units were fixed separately depending on cost of production and capacity utilisation norms, and the difference between this price and the farm-gate price was paid out as budgetary subsidy. Thus the scheme assured a minimum level of profits and thus attracted investment.

Government not only encouraged the setting up of new capacity through its policies, it itself participated in the production of fertiliser. The share of public sector financial outlays in total outlays increased from 59% in 1973-74 to 68% in 1978-79. After that it declined a bit, but in 1993-94, at 63%, it still had a substantial share.

There was substantial increase in financial outlays and expansion of capacity during 1973-93. Financial outlay on fertiliser which was Rs. 783 crores in 1973-74 rose to 1757 crores in 1978-79. This meant an increase of 125% in 5 years. By 1993-94, this figure had risen to Rs.11,378 crores which meant an increase of 550% in 15 years. As a result productive capacity for fertilisers (both Nitrogen and Phosphatic) increased from 2.5 mn tonnes in 1973-74 to 4.391 in 1978-79 representing an increase of 73% and to 11.344 mn tonnes in 1993-94, a further increase of 158%.[7]

Capacity expansion was accompanied by an increase in the number of factories from 341 in the beginning of the period to 598 towards the end. Simultaneously, the size of the firms and the scale of operations increased. Thus average size of the firm in terms of gross fixed capital (at constant prices) increased form Rs.184 lakhs to Rs. 264.7 lakhs. Also, scale of operations defined as average output increased from 131 lakhs to 614 lakhs. The managerial and operational economies associated with these size and scale factors are well recognised in the literature.

Along with expansion there was fuller utilisation of existing capacity. Capacity utilisation increased from 53% in 1980-81 to 88% in 1993-94 for Nitrogenous fertilisers and from 65% to 83% for phosphatic fertilisers.[8] Fuller utilisation had the effect of lowering costs through greater efficiency of input use.

Expansion of capacity was accompanied by significant qualitative changes in the physical composition of capital. This development took two directions.

First, there was a significant change in the overall feed-stock base of the fertiliser industry. There was a move away from setting up plants based on coal, coke or coke-oven gas,

[7] FAI, Fertiliser Statistics, 1994-95, page I-24.
[8] FAI, Fertiliser Statistics, 1994-95, page I-32.

and towards relatively more efficient feed-stocks like fuel oil, naphtha, and natural gas. The only exceptions regarding coal and coke were, where these products were available as by product of some other process like at steel plants. With the commissioning of HBJ pipe line, almost the entire new capacity was based on natural gas.

Secondly, and more importantly, within natural gas plants there was a move towards more efficient plants in terms of energy and materials. An indirect evidence on this second point is provided by decline in energy used per unit of capital (E/K) over time. Table 8.1 can be used to infer trends in this ratio. (E/K=(Y/K)/(Y/E)). There was a 52 % drop in this ratio between 1973 and 1993 indicating a decline at the rate of 4.3% per annum. This decline can be interpreted to mean that newer and more and more energy efficient plants and processes came to dominate the overall capacity.

9. Glass

Glass industry (subgroup 321) is the smallest of the six in terms of size of output and capital stock. Average level of output for the years 1973-75 and 1991-93 are shown in Figure 9.0 below, and their growth rates are shown in Table 9.0a.

Table 9.0: Output and Inputs: Glass Industry

Average	Output	Capital	Labour	Energy	Materials	No of factories
1973-75	7644	3397	55369	1502	3438	399
1991-93	30040	15643	60634	4088	32180	628

Notes:
Figures are in const. lakhs of Rupees (1973-74 values), except labour and factories which are numbers.
Figures are averages for three years at the beginning and end of the period of study.

The industry's output of Rs. 0.30 billion accounted for 0.32 percent of the output in the manufacturing sector. It accounted for only 0.4% of the total fixed capital and had a 0.7 per cent share in employment. This share was the smallest except for the aluminium industry. The industry's share in energy consumption was 1.4% of the total, and was the smallest in agreement with the size of its output. The energy intensity or the share of energy costs in the value of output was 13.61 percent. This was figure was 30% lower compared to the figure in the beginning of the period.

The indices of output and inputs in the glass industry during 1973-93 are shown in Figure 9.0, and their growth rates are summarised in Table 9.0a below.

During the years 1973-93 the value of output grew at the rate of 7.9 per cent per annum. This growth was achieved by a major expansion in capital input which increased at the rate of 8.9 per cent per annum. There was little increase in labour employment, its rate of growth only being 0.15 per cent per annum. Both the use of energy and material inputs showed significant increase; their rates of growth being 5.7 and 6. 5 per cent per annum respectively.

Figure 9.0: Output and Input Indices: Glass (based on const. 1973-74 values)

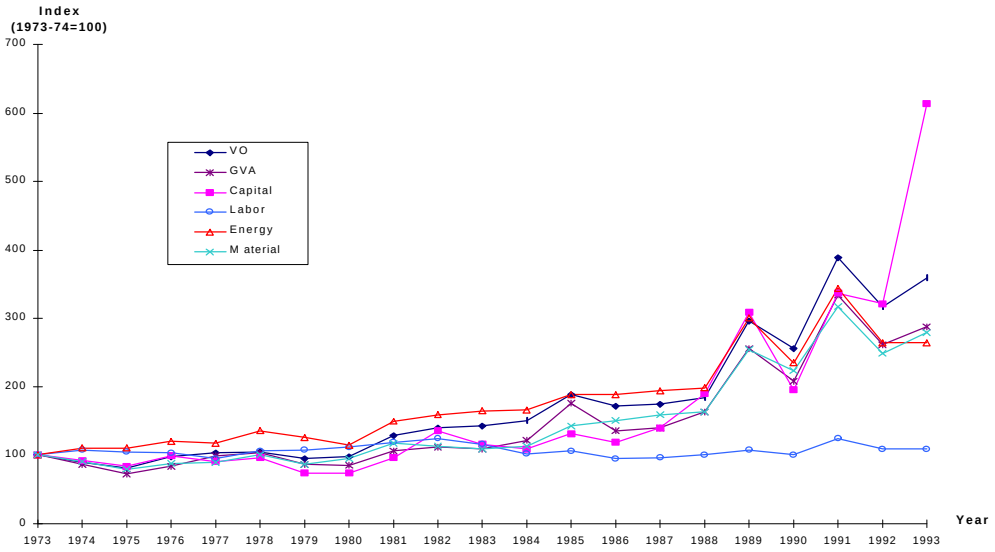


Table 9.0.a: Growth of Output and Inputs: Glass

Year	Output	Capital	Labour	Energy	Materials
1973/75 - 80/82	4.44	1.46	1.88	4.03	2.68
1980/82 - 91/93	10.16	13.84	-0.36	6.81	9.05
1973/75 - 91/93	7.90	8.85	0.50	5.72	6.52

Note: Figures are compound annual growth rates between the three year periods for which average values for the relevant parameters were taken.

9.1 Partial Productivity Growth

Partial productivity ratios for two factor inputs, capital and labour and two non-factor inputs, energy and materials are given in Table 9.1. This table also shows changes in capital per head over time. The same information is presented in an indexed form in the even numbered figure. Information on partial productivity growth in the glass industry is summarised in Table 9.1a below:

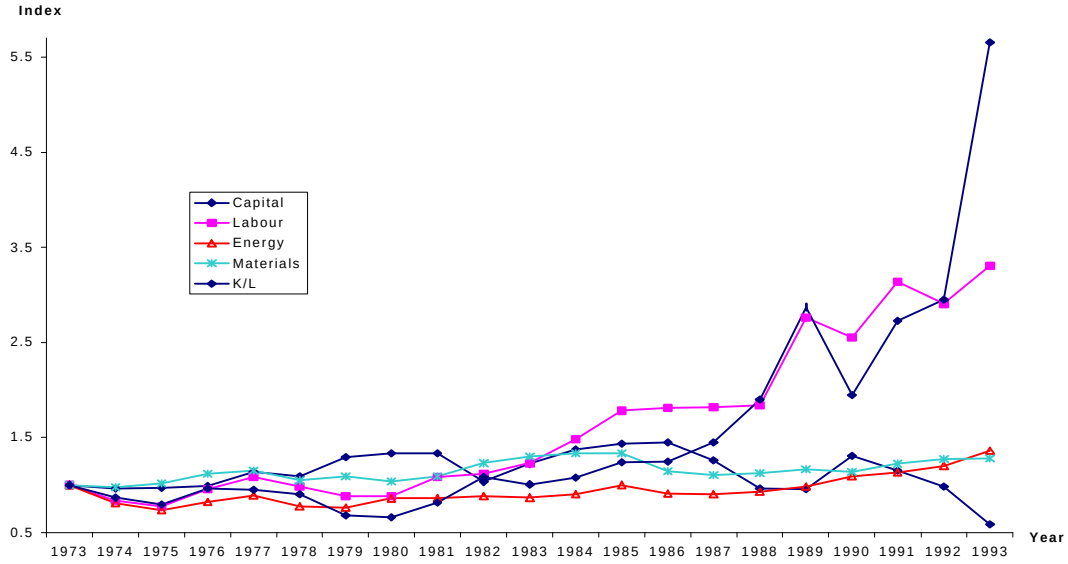
Expansion of capital was not matched by productivity growth which stagnated with a rate of -0.42 per cent. Labour productivity increase during this period with a rate of 7.34 per cent per annum. This could partly be explained by a 8.37 per cent per annum growth rate of capital intensity.

Productivity of energy increased at the rate of 2.1 per cent per annum with energy requirement per unit of output, on an average, being lower by 30% at the end of the period. There was a moderate increase in the productivity of material use which registered a rate of 1.3 % p.a.

Table 9.1: Partial Productivity Ratios: Glass

Year	Capital	Labour	Energy	Materials	K/L
1973	2.30	0.16	6.02	2.23	0.07
1974	2.22	0.13	4.90	2.18	0.06
1975	2.23	0.12	4.43	2.26	0.06
1976	2.28	0.15	4.95	2.49	0.07
1977	2.62	0.17	5.34	2.58	0.07
1978	2.50	0.16	4.68	2.33	0.06
1979	2.97	0.14	4.58	2.43	0.05
1980	3.06	0.14	5.17	2.31	0.05
1981	3.06	0.17	5.20	2.43	0.06
1982	2.37	0.18	5.30	2.74	0.08
1983	2.81	0.20	5.22	2.90	0.07
1984	3.16	0.24	5.44	2.97	0.07
1985	3.30	0.28	6.03	2.97	0.09
1986	3.33	0.29	5.49	2.55	0.09
1987	2.89	0.29	5.42	2.46	0.10
1988	2.22	0.29	5.59	2.50	0.13
1989	2.20	0.44	5.93	2.59	0.20
1990	3.01	0.41	6.56	2.54	0.13
1991	2.65	0.50	6.80	2.72	0.19
1992	2.26	0.46	7.23	2.84	0.20
1993	1.34	0.53	8.18	2.85	0.39

Figure 9.1: Partial Productivity Indices (based on const. 1973-74 values)



Changes in productivity of different inputs were not uniform over the entire period. As this figure above indicates, there appears to be a break in or a modification of the trends in different series around the year 1981-82. There was a dramatic change in the growth of K/L ratios between the two periods. From a negative growth of around 3% per annum, it jumped to 14.58 per cent per annum. Under its influence capital productivity growth turned reversed from

4.34% per annum to -2.73per cent per annum, while labour productivity growth jumped from only 1.2% to 10.5% per annum. There was a big boost to energy productivity growth which changed from a low negative figure of -0.36 to 3.52% per annum. Growth of material productivity declined to less than half of its level in the first period.

Table 9.1.a Partial Productivity Growth:Glass (% p.a.)

	Capital	Labour	Energy	Materials	K/L
CAGR					
1973-82	3.35	2.42	0.30	1.65	- 0.57
1982-93	-2.75	10.59	3.22	1.07	14.48
1973-93	- 0.42	7.34	2.08	1.30	8.37
Trend rate					
1973-93	-0.38	7.31	1.91	0.99	7.69
t-statistic	(- 0.49)	(12.59)	(5.27)	(3.76)	(6.93)
R-square	0.01	0.89	0.59	0.43	0.72

9.2 Total Productivity Growth

Three alternative indices of total productivity growth are shown in Table 9.2 and illustrated in even numbered figure. Further, the growth experience is summarised in Table 9.2a.

Table 9.2: Total Productivity Indices: Glass

Year	Translog		Solow		Kendrick	
1973	1		1		1	
1974	0.92	(-8.54)	0.92	(-8.16)	0.91	(-8.70)
1975	0.90	(-1.91)	0.90	(-1.74)	0.89	(-2.34)
1976	1.00	(10.27)	1.01	(11.66)	0.99	(11.14)
1977	1.09	(8.37)	1.09	(8.18)	1.08	(8.70)
1978	0.99	(-9.05)	0.98	(-9.69)	0.98	(-9.10)
1979	1.03	(3.80)	1.02	(3.27)	1.00	(2.09)
1980	1.05	(1.51)	1.03	(1.35)	1.02	(1.58)
1981	1.10	(4.92)	1.09	(6.15)	1.08	(6.23)
Average 1973-81		1.17		1.38		1.20
1982	1.09	(-0.82)	1.07	(-2.26)	1.08	(0.27)
1983	1.17	(6.86)	1.14	(6.78)	1.16	(7.31)
1984	1.25	(7.03)	1.22	(6.98)	1.25	(7.56)
1985	1.33	(6.01)	1.31	(7.24)	1.33	(6.41)
1986	1.23	(-7.66)	1.21	(-7.37)	1.22	(-8.06)
1987	1.17	(-5.09)	1.15	(-5.52)	1.17	(-4.55)
1988	1.11	(-4.91)	1.08	(-5.74)	1.11	(-4.35)
1989	1.20	(7.22)	1.20	(10.74)	1.19	(6.58)
1990	1.31	(8.96)	1.28	(7.09)	1.29	(8.90)
1991	1.34	(2.46)	1.32	(3.38)	1.33	(2.62)
1992	1.32	(-1.98)	1.30	(-1.96)	1.30	(-1.80)
1993	1.19	(-9.77)	1.09	(-16.14)	1.12	(-14.25)
Average 1982-93		0.83		0.50		0.58

Note: Figures in parentheses are year to year growth rates.

Figure 9.2: Total Productivity Indices: Glass (based on const. 1973-74 values)

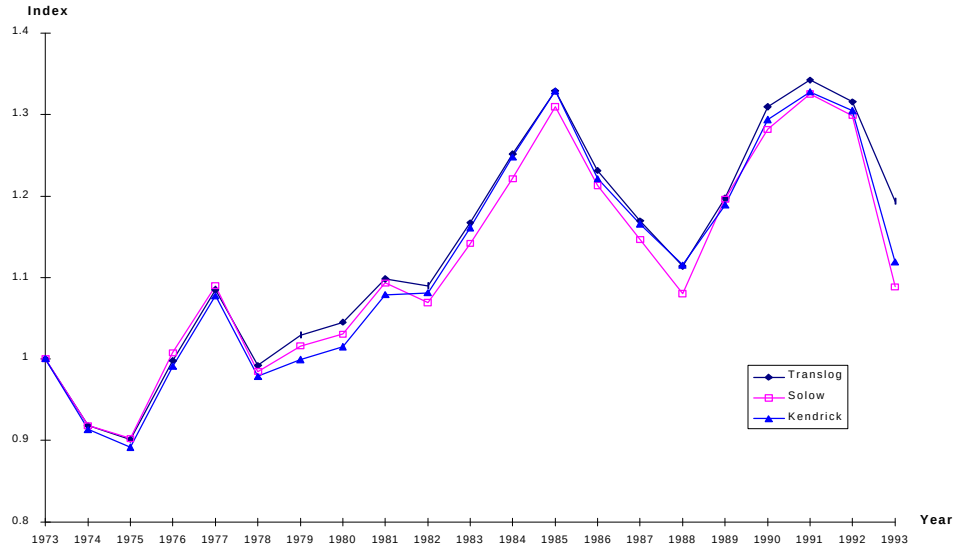


Table 9.2.a: Total Productivity Growth: Glass

	Translog	Solow	Kendrick
CAGR			
1973-82	1.98	1.79	1.79
1982-93	1.60	1.38	1.52
1973-93	1.75	1.54	1.63
Trend rate			
1973-93	1.66	1.46	1.6
t-statistic	(7.34)	(5.70)	(6.28)
R-square	0.74	0.63	0.68

Total productivity increased significantly, at the rate of 1.7 per cent per annum. Solow and Kendrick indices are broadly in agreement with these findings. Growth was positive throughout the period, with a slight decline between the first and the second periods.

9.3 Policy Environment and Productivity Growth

It appears that both the size and the scale effect were important in explaining productivity growth in Glass Industry. Average level of output increased from 19 lakhs in 1973/75 to 478 lakhs in 1991/93, a 25 times increase. Similarly, average size of the capital stock increased from 8.51 to 24.9 lakhs, a three fold increase.

There is evidence also that over time the quality of capital from the point of view of using energy improved. This is reflected in E/K ratio over time, which registered a decline of 35% over the period.

10. Iron and Steel

Iron and steel industry (subgroup 330) has been considered the backbone of India's industrialisation programme. Average levels of output and inputs for the beginning and the end of the period of our study are given in Table 10.0 below.

Table 10.0: Output and Inputs: Iron and Steel Industry

Average	Output	Capital	Labour	Energy	Materials	No of factories
1973-75	123074	86168	228018	12448	60570	1068
1991-93	470583	522666	351480	38815	359847	1780

Notes:
Figures are in const. lakhs of Rupees (1973-74 values), except labour and factories which are numbers.
Figures are averages for three years at the beginning and end of the period of study.

During 1991-93, the industry's output level of Rs. 4.7 bn, was 5.6% of output in the manufacturing sector as a whole. The industry accounted for 13% of the stock of fixed capital and 4.6% of the labour force of the total manufacturing sector. Similarly, energy and materials consumption accounted for 9.87 and 7.7 respectively per cent of the aggregate manufacturing. It was the largest of the six industries in terms of the size of the output, capital and labour force and also in terms of energy and materials consumed.

Energy costs formed 8.25% of value of output. This figure was double of that in the total manufacturing sector, but lower than the figure for other industries. Also, it was 18% or so lower than the figure in the beginning of the period.

The indices of output and inputs in the industry during 1973-93 are shown in figure 10.0 below, and their growth rates in Table 10.0a.

Figure 10.0: Output and Input Indices: Iron and Steel (based on const. 1973-74 values)

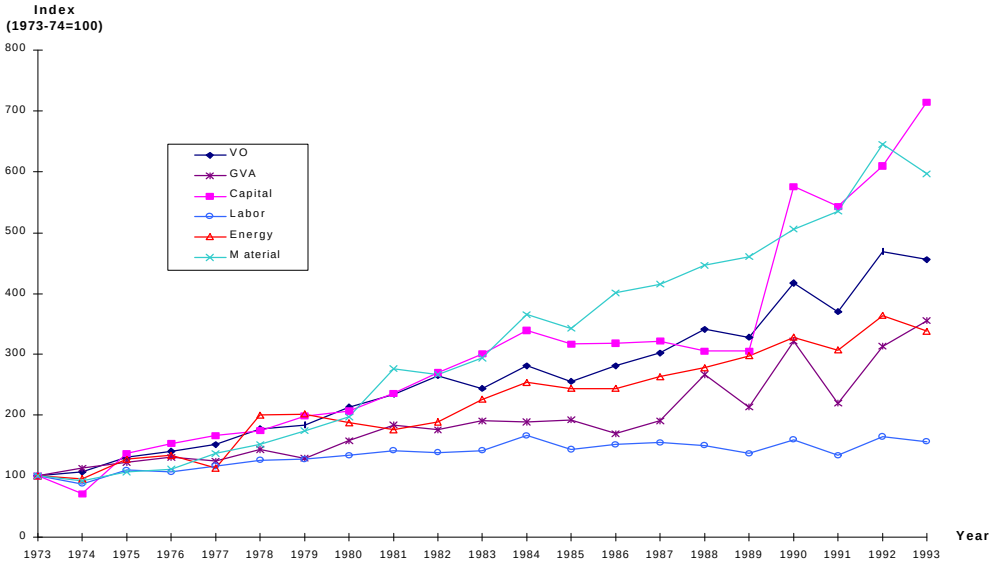


Table 10.0.a: Growth of Output and Inputs: Iron and Steel

Year	Output	Capital	Labour	Energy	Materials
1973/75 - 80/82	11.2	12.71	4.93	8.00	13.87
1980/82 - 91/93	5.58	9.17	0.87	5.59	8.28
1973/75 - 91/93	7.73	10.53	2.43	6.52	10.41

Note: Figures are compound annual growth rates between the three year periods for which average values for the relevant parameters were taken.

Output grew at the rate of 7.7 percent per annum during 1991-93. During the same period, the stock of gross fixed capital and labour force increased at the rate of 10.5 per cent per annum, and 2.4 per cent per annum respectively. These were accompanied by growth in energy and material inputs at the rates of 6.5 and 10.4 per cent per annum respectively. The implied elasticity of consumption of energy with respect to output was 0.84. However, if we consider the post 1981 period as relevant this elasticity is slightly greater than unity. This has the implication that in the near future, as output expands, there is likely to be an increase in demand for energy by the same percentage.

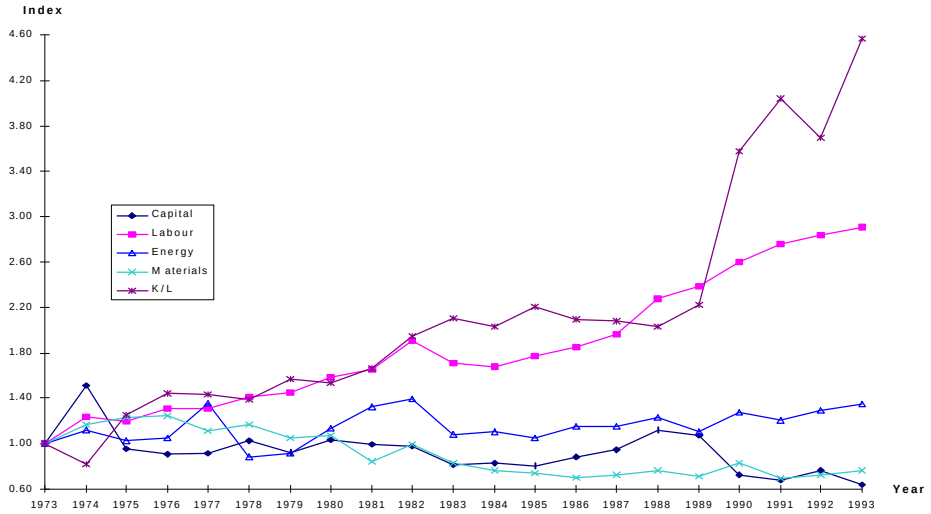
10.1 Partial Productivity Growth

Partial productivity ratios for two factor inputs, capital and labour and two non-factor inputs, energy and materials are given in Table 10.1. This table also shows changes in capital per head over time. The same information is presented in an indexed form in the even numbered figure.

Table 10.1: Partial Productivity Ratios: Iron and Steel

Year	Capital	Labour	Energy	Materials	K/L
1973	1.30	0.47	9.44	1.79	0.36
1974	1.96	0.58	10.59	2.09	0.30
1975	1.24	0.57	9.71	2.20	0.46
1976	1.18	0.62	9.89	2.24	0.52
1977	1.18	0.62	12.78	1.99	0.52
1978	1.33	0.67	8.35	2.09	0.50
1979	1.20	0.68	8.62	1.89	0.57
1980	1.34	0.75	10.69	1.93	0.56
1981	1.29	0.78	12.54	1.52	0.61
1982	1.27	0.90	13.17	1.78	0.71
1983	1.06	0.81	10.21	1.49	0.76
1984	1.07	0.79	10.44	1.38	0.74
1985	1.04	0.83	9.89	1.33	0.80
1986	1.15	0.87	10.86	1.26	0.76
1987	1.23	0.93	10.86	1.31	0.75
1988	1.45	1.07	11.58	1.37	0.74
1989	1.40	1.13	10.40	1.28	0.81
1990	0.94	1.23	12.04	1.48	1.30
1991	0.89	1.30	11.40	1.24	1.47
1992	1.00	1.34	12.19	1.30	1.34
1993	0.83	1.37	12.71	1.37	1.66

Figure 10.1: Partial Productivity Indices (based on const. 1973-74 values)



For highlighting important trends the information on partial productivity growth in the iron and steel industry is summarised in Table 10.1a below:

Table 10.1.a: Partial Productivity Growth: Iron and Steel (% p.a.)

	Capital	Labour	Energy	Materials	K/L
CAGR					
1973/75-80/82	- 2.03	5.93	2.93	-2.14	7.65
1980/82-91/93	-3.26	4.67	-0.02	-2.60	8.24
1973/75-91/93	-2.78	5.16	1.11	-2.42	8.01
Trend rate					
1973-93	-1.87	4.83	0.98	-2.92	6.71
t-statistic	(-3.4)	(20.85)	(2.4)	(-7.68)	(12.27)
R-Square	0.38	0.96	0.23	0.76	0.89

Productivity of capital declined at the rate of 2.8 per cent per annum during 1973-93. Labour productivity increased during this period at the rate of 5.2 per cent per annum. This could partly be explained by 8.0 per cent per annum growth rate of capital intensity. Productivity of energy increased at the rate of 1.1 per cent per annum. Reflective of this was a 50% decline in the E/K ratio at the end of the period compared to at the beginning. There was a significant decline in the productivity of material use at the rate of 2.4 per cent per annum.

Changes in productivity of different inputs were not uniform over the entire period. The decline in productivity of capital accelerated while the growth of labour productivity decelerated between the first and the second periods. These changes were reflective of an increase in the rate of growth of capital intensity. Energy productivity which was increasing at a significant rate became near zero. Similarly the efficiency with which materials are used worsened considerably between the first and the second periods.

10.2 Total Productivity Growth

Indices of total productivity in terms of the three measures are shown in Table 10.2 and illustrated in even numbered figure. Further, the growth experience is summarised in Table 10.2a.

Table 10.2: Total Productivity Indices: Iron and Steel

Year	Translog		Solow		Kendrick	
1973	1		1		1	
1974	1.24	(21.47)	1.19	(19.46)	1.24	(23.570
1975	1.11	(-10.83)	0.99	(-17.21)	1.12	(-8.96)
1976	1.12	(0.74)	1.00	(0.77)	1.13	(0.62)
1977	1.09	(-2.65)	0.97	(-2.88)	1.10	(-2.60)
1978	1.10	(0.81)	0.97	(0.55)	1.12	(1.23)
1979	1.02	(-7.08)	0.90	(-7.69)	1.04	(-6.78)
1980	1.10	(7.48)	0.97	(8.09)	1.12	(7.89)
1981	0.99	(-11.09)	0.83	(-14.27)	0.99	(-11.39)
Average 1973-81		- 0.14		- 1.65		0.45
1982	1.08	(8.80)	0.91	(9.82)	1.11	(11.12)
1983	0.89	(-18.80)	0.74	(-19.12)	0.92	(-16.98)
1984	0.86	(-3.60)	0.71	(-4.08)	0.88	(-3.64)
1985	0.84	(-2.77)	0.69	(-2.50)	0.86	(-2.80)
1986	0.84	(0.18)	0.69	(0.29)	0.86	(0.04)
1987	0.87	(3.89)	0.72	(4.08)	0.90	(4.20)
1988	0.95	(8.35)	0.78	(8.58)	0.97	(8.47)
1989	0.90	(-5.92)	0.74	(-5.84)	0.91	(-5.93)
1990	0.90	(0.80)	0.75	(1.27)	0.93	(1.44)
1991	0.80	(-12.23)	0.66	(-11.07)	0.82	(-11.58)
1992	0.85	(6.43)	0.72	(7.79)	0.88	(7.06)
1993	0.85	(-0.77)	0.71	(-0.92)	0.86	(-2.05)
Average 1982-93		- 2.22		- 1.96		- 1.98

Note: Figures in parentheses are year to year growth rates.

Total productivity declined throughout 1973-93. The overall rate of decline being 1.62 per cent per annum. Productivity growth thus contributed - 21% to output growth. This means that expansion of inputs, mainly capital and materials, contributed 121%. Both sub-periods were characterised by the decline, which actually accelerated in the second period. This was contrary to the growth trends in the manufacturing sector.

Figure 10.2: Total Productivity Indices (based on const. 1973-74 values)

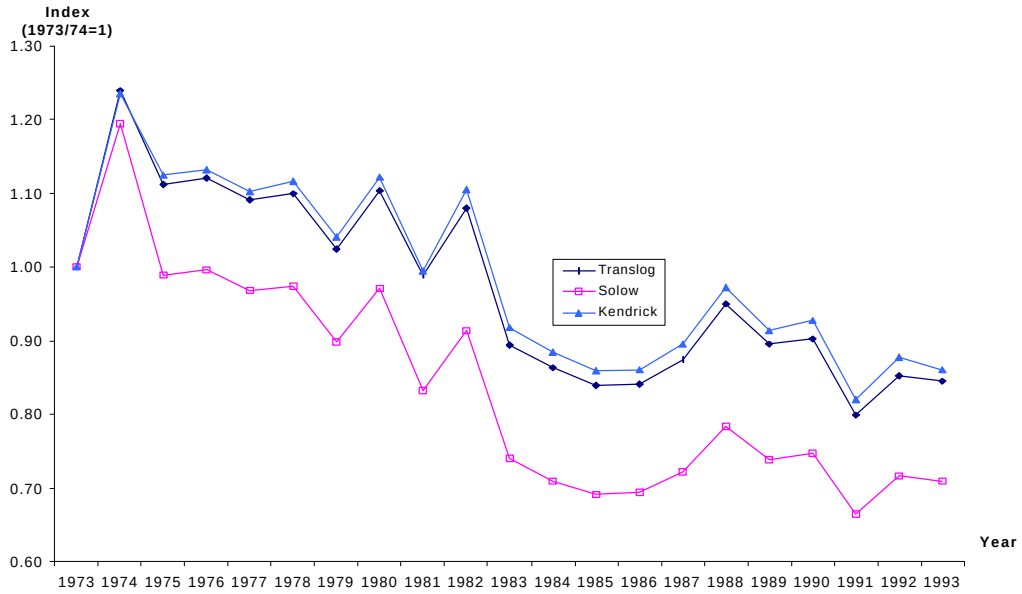


Table 10.2.a: Total Productivity Growth: Iron and Steel

	Translog	Solow	Kendrick
CAGR			
1973/75-80/82	- 0.78	- 2.23	- 0.60
1980/82-91/93	- 2.16	- 2.36	- 2.08
1973/75-91/93	- 1.62	- 2.31	- 1.51
Trend rate			
1973-93	-1.71	-2.39	-1.59
t-statistic	(-6.84)	(-8.16)	(-6.31)
R-square	0.70	0.78	0.68

10.3 Policy Perspective and Productivity Growth

Iron and steel industry did not benefit to the same extent as Cement and Fertiliser industries from changes in industrial policy outlined by us earlier. Constraints of market on account of industrial recession, infrastructural bottlenecks like non-availability of power, problems of raw material quality and supply, the state of industrial relations and organisational inefficiency of public sector were the main reasons for negative productivity growth. For the public sector steel plants, which accounted for 82% of ingot steel capacity, its utilisation was around 66% in the first sub-period, and was as low as 58% in 1980-81. This was in contrast with over 93% average capacity utilisation by the private sector TISCO. Similarly, with a 90% share of saleable steel capacity, its utilisation was only around 65% in the first period. In the second sub-period, capacity utilisation on the two counts increased to 71% and 78%, but it failed to increase productivity, driving home the point that no single factor alone can be used to explain growth, or the lack of it.

Public sector steel industry had a wide variety of technologies of different vintages existing side by side. It was failure to modernise on a sufficiently large scale which was the main

reason for lack of productivity. Unlike, in the private sector, the decision making process in the public sector was a long drawn one and spread over many agencies. Therefore, decisions for investment for modernisation and technological upgradation could not be taken expeditiously. This was particularly serious as process imbalances appeared over time due to deterioration of quality of coal and other raw materials, which could not be handled by the existing technologies. Even when proven new technologies emerged and were even adopted in some cases, e.g. basic oxygen converter at Rourkela, old ones like open hearth at Durgapur and Bessemer cum tilting open hearth at IISCO were retained. This was the reason why energy efficiency could improve in Indian steel plants only a little.

The public sector worked under the constraint of fulfilling multiple social objectives instead of focusing on profitability. Thus plants were set up in different places not on the criteria of minimum costs, but for ensuring regional balance in industrialisation. For long the dominant objective of public sector steel plants had been output maximisation. After a review in 1981-82, there was a policy shift and profitability was emphasised. There was a some improvement in the financial parameters but because of old orientation towards maximising tonnage and lack of timely action, technological up-gradation lagged and decline in productivity continued.

11. Paper and Paper Products

Paper and paper products (subgroup 280, 281, 282, 283) is considered basic to the development of social and general infrastructure of the economy. Besides the industry has an important role in packaging. In India, the per capita consumption of paper and paper products in only 2.9 kgs, as compared with 40 kgs in the Asia and Pacific Region and as much as 334 kgs in the U.S.A. With rising population, increasing disposable income and the spread of literacy, demand for paper will increase substantially.

Average levels of output and inputs for the beginning and the end of the period of our study are given in Table 11.0 below.

Table 11.0: Output and Inputs: Paper Industry

Average	Output	Capital	Labour	Energy	Materials	No. of factories
1973-75	37374	18466	94931	3147	17940	943
1991-93	96372	71235	153027	13240	53412	2330

Notes:
Figures are in const. lakhs of Rupees (1973-74 values), except labour and factories which are numbers.
Figures are averages for three years at the beginning and end of the period of study.

Paper industry produced an average output worth Rs. 0.96 bn. During the years 1991-93. This constituted only 1.15% of the out put in the manufacturing sector as a whole. The stock of fixed capital was 1.8% of the total capital stock. With an energy consumption level which accounted for 3.37% of total energy consumed, the energy intensity of output in this sector was 13.7% which was the third highest among the six industries. This indicated a 63% increase over the level in the beginning of the period.

The indices of output and inputs in the paper industry during 1973-93 are shown in Figure 11.0 and their growth rates are shown in Table 11.0.a below.

Figure 11.0: Output and Input Indices: Paper Industry (based on const. 1973-74 values)

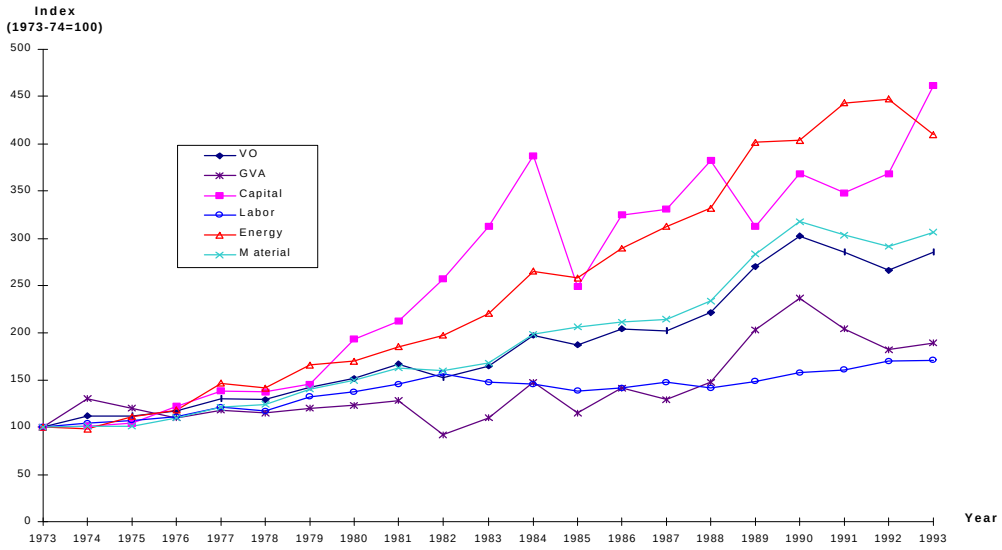


Table 11.0.a: Growth of Output and Inputs: Paper Industry

Year	Output	Capital	Labour	Energy	Materials
1973/75 - 80/82	5.46	11.73	5.07	8.67	6.57
1980/82 - 91/93	5.36	5.36	1.19	8.08	6.04
1973/75 - 91/93	5.40	7.79	2.69	8.31	6.25

Note: Figures are compound annual growth rates between the three year periods for which average values for the relevant parameters were taken.

Output grew at the rate of 5.4% during the years 1973-93. During the same period the stock of gross fixed capital increased at the rate of 7.8 % per annum, while labour force increased at the rate of 2.7 % per annum. These were accompanied by growth in energy and material inputs at the rates of 8.3 % and 6.3% per annum respectively. The implied elasticity of energy use with respect to output was 1.57, the highest among the six industries. On the margin then a one percent increase in output will call forth increase in energy use by a 1.6 percent.

11.1 Partial Productivity Growth

Partial productivity ratios for two factor inputs, capital and labour and two non-factor inputs, energy and materials are given in Table 11.1. This table also shows changes in capital per head over time. The same information is presented in an indexed form in the even numbered figure. Partial productivity growth rates in the paper industry are summarised in Table 11.1.a below.

During 1973-93, productivity of capital declined at the rate of - 2.14 % per annum, while that of labour increased a the rate of 2.65 % per annum. The increase in labour productivity was to an extent the result of the process of capital deepening , or the increase in the availability of

capital per head which registered a trend rate of growth of 4.96 % per annum. The productivity of energy declined at the rate of 2.68 % per annum, indicating increasing energy intensity in the production of paper. Material intensity of production increased by an insignificant amount with its productivity ratio declining at the rate of 0.79 % per annum.

Table 11.1: Partial Productivity Ratios

Year	Capital	Labour	Energy	Materials	K/L
1973	1.90	0.38	11.30	1.94	0.20
1974	2.12	0.41	12.92	2.16	0.19
1975	2.05	0.39	11.47	2.15	0.19
1976	1.83	0.40	11.24	2.07	0.22
1977	1.79	0.40	10.03	2.08	0.23
1978	1.79	0.42	10.35	2.02	0.23
1979	1.86	0.41	9.72	1.97	0.22
1980	1.49	0.41	10.07	1.97	0.28
1981	1.49	0.43	10.17	1.98	0.29
1982	1.13	0.37	8.76	1.86	0.33
1983	1.00	0.42	8.46	1.91	0.42
1984	0.97	0.51	8.42	1.93	0.53
1985	1.43	0.51	8.22	1.76	0.36
1986	1.19	0.54	7.96	1.87	0.45
1987	1.16	0.52	7.31	1.83	0.45
1988	1.10	0.59	7.54	1.84	0.53
1989	1.64	0.68	7.59	1.85	0.42
1990	1.56	0.72	8.48	1.85	0.46
1991	1.56	0.67	7.28	1.83	0.43
1992	1.37	0.59	6.73	1.77	0.43
1993	1.18	0.63	7.88	1.81	0.53

Figure 11.1: Partial Productivity Indices (based on const. 1973-74 values)

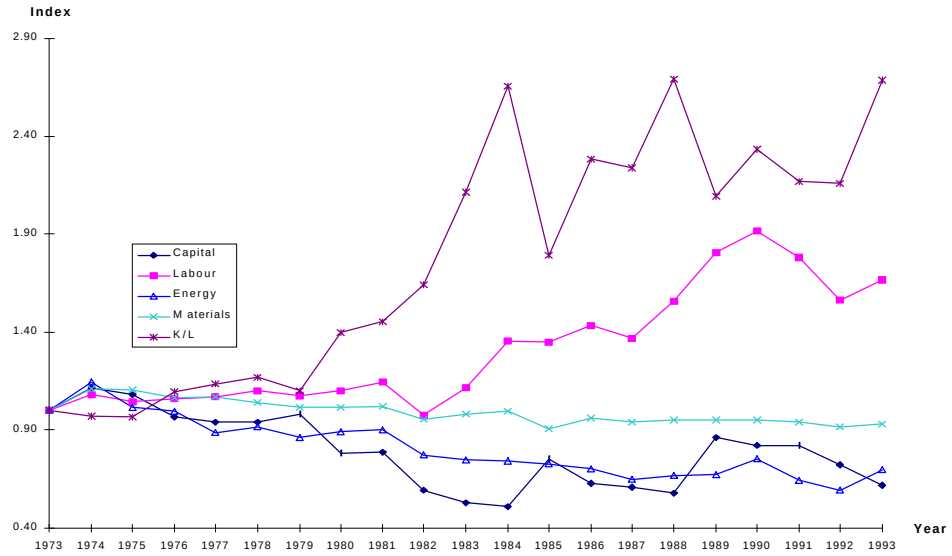


Table 11.1.a: Partial Productivity Growth (% p.a.)

	Capital	Labour	Energy	Materials	K/L
CAGR 1973/75-80/82	-5.41	0.42	-2.93	-1.03	6.28
1980/82-91/93	-0.01	4.10	-2.52	-0.65	4.13
1973/75-91/93	-2.14	2.65	-2.68	-0.79	4.96
Trend rate 1973-93	-2.3	3.14	-2.68	-0.82	5.44
t-statistic	(3.24)	(8.81)	(10.89)	(7.24)	(9.64)
R-square	0.36	0.80	0.86	0.73	0.83

Energy use per unit of capital decline from an average of 5.87 to 5.419 during th period of our study. At the end of the period a unit of capital was using 7.6% less energy compared to at the beginning.

Changes in productivity of different inputs were not uniform over the entire period. The strong negative growth of capital reversed itself into a positive small growth rate which was insufficient to turn the overall period growth into a positive figure. Labour productivity got a big jump between the two periods, which unlike in the case of other industries was not the result of acceleration in the capital intensity.

For energy, there was a moderation of productivity decline between the two periods with rate of growth going up from -2.47 % per annum to - 2.21 % per annum. For the materials sector too there was a marginal decrease in the rate of decline of productivity between the two periods.

11.2 Total Productivity Growth

Indices of total productivity in terms of the three alternative measures are given in Table 11.2 and shown in the accompanying figure. A summary of growth trends is given in Table 11.2a.

Table 11.2: Total Productivity Indices

Year	Translog		Solow		Kendrick	
1973	1		1		1	
1974	1.11	10.67	1.11	11.32	1.11	11.27
1975	1.08	-2.73	1.08	-2.74	1.08	-2.67
1976	1.03	-5.42	1.02	-6.08	1.02	-5.45
1977	1.01	-1.73	1.00	-1.95	1.01	-1.65
1978	1.00	-0.67	0.99	-0.67	1.00	-0.66
1979	0.99	-1.16	0.98	-1.34	0.99	-0.67
1980	0.94	-5.10	0.92	-6.33	0.92	-6.93
1981	0.95	0.85	0.92	0.92	0.93	0.75
Average 1973-81		- 0.66		- 0.86		- 0.75
1982	0.83	-13.33	0.79	-14.08	0.79	-15.24
1983	0.83	-0.29	0.79	-0.41	0.76	-3.63
1984	0.84	1.56	0.81	1.89	0.76	0.09
1985	0.87	3.22	0.82	2.37	0.86	13.26
1986	0.86	-0.56	0.82	-0.70	0.83	-4.34

Table 11.2 continued: Total Productivity Indices

Year	Translog		Solow		Kendrick	
1987	0.83	-3.59	0.79	-3.64	0.80	-3.22
1988	0.84	0.82	0.80	0.95	0.79	-0.89
1989	0.94	10.89	0.88	10.55	0.94	18.12
1990	0.94	0.75	0.89	0.78	0.93	-0.07
1991	0.91	-3.45	0.86	-3.31	0.91	-2.82
1992	0.85	-6.70	0.80	-6.60	0.84	-7.33
1993	0.85	0.29	0.80	0.03	0.82	-3.06
Average 1982-93		0.26		0.17		0.55

Note: Figures in parentheses are year to year growth rates.

Figure 11.2: Total Productivity Indices: Paper Industry (based on const. 1973-74 values)

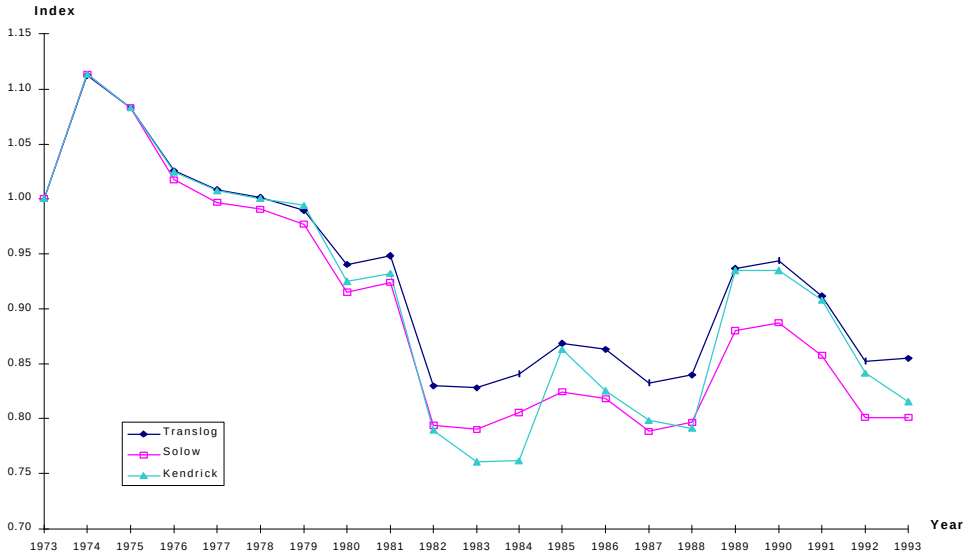


Table 11.2.a: Total Productivity Growth (% p.a.)

	Translog	Solow	Kendrick
CAGR			
1973/75-80/82	-1.48	-1.79	-1.62
1980/82-91/93	0.05	-0.19	0.33
1973/75-91/93	-1.10	-1.44	-1.21
Trend rate			
1973-93	- 1.10	- 1.45	- 1.25
t-statistic	(-4.41)	(-5.83)	(- 38.7)
R-square	0.53	0.64	0.44

There was a decline in total productivity through out the period 1973-93, with the overall rate of decline being 1.1% per annum. There was a broad agreement among the three measures on this. The implication of this is that inputs contributed more than 101% to the growth of output.

There was a modification of trend of productivity growth between the first and the second sub-periods. There was a sharp decline in productivity in the first sub-period, followed by a low positive growth rate in the second period.

11.3 Policy Environment and Productivity Growth

Lack of productivity growth in the paper industry can be largely explained by trends in creation and utilisation of capacity.

From the beginning of the planning era, paper industry was subject to licensing but it development was left to the initiative and enterprise of the private sector. Keeping in view the importance of industry in the national economy, and the large scale of investment required, Industrial policy statements of 1970 and 1973 placed paper first in the `heavy' industry sector and then in the `core' sector, to make it possible large industrial houses to contribute to the establishment of this industry.

In 1975, the policy was further liberalised. In view of its capital intensive nature and inclusion in the core sector, paper industry was exempted from obtaining an industrial license for effecting substantial expansion, provided the articles were not reserved for the manufacture in the small sector and the undertaking did not fall within the purview of the MRTP Act or FERA Act, and if installation of additional machinery was not involved. In February 1985, subject to their not falling within the MRTP Act and FERA, the industry was removed from the purview of industrial licensing.

Consistent with the importance accorded to it in successive policy statements, the industry made rapid progress during the planning era. In 1973-74, the industry had an installed capacity of 10 lakh tonnes compared to a mere 1.4 lakh tonnes in 1951. By the end of 6^{th} plan, the capacity had risen to 27 lakh tonnes, ahead of the target set in the plan. In the late seventies, apart from the setting up of large integrated mills, there has been a considerable increase in the number of small-sized paper mills.

The increase in capacity was not matched by the increase in production. Mark the widening gap between the size of the capital stock and output in Figure 11.0 above and the difference in their growth rates shown in Table 11.0a. Capacity utilisation in 1973-74 was 78.9%. This was 4.7% less than the previous year. By 1981, capacity utilisation had fallen to 68.5%. By 1986, it was as low as 62.1%. The decline in productivity of capital indicated in Table 11.1a reflects to a large extent idle capacity. Similarly, the increase in labour productivity shows slower rise of labour compared to that of capital.

The decline in capacity utilisation was mainly due to inadequate availability of raw materials, lack of infrastructural support in general and that of power supply in particular. High cost of inputs and demand recession led to mill closures which also contributed to underutilisation of capacity. In 1985, there were four large integrated mills accounting to 2 lakh tonnes capacity besides many smaller mills with 0.92 lakh tonnes were closed. In general, smaller mills had much

lower levels of capacity utilisation compared to large integrated mills. In 1985, the levels of capacity utilisation in two kinds of mills were 50% and 71% respectively.

Because of a large amount of capacity in the seventies was coming from small paper mills, the industry is unlikely to have benefited from size and scale economies. Thus over the 21 years of period of our study, the average size of the firm had increased from 20 lakhs to 30 lakhs only. Also, the average level of output had increased from 40 lakhs to 41 lakhs. Other reasons for low or negative productivity growth can be attributed to lack of any significant technological change and also lack of adequate and timely modernisation.[9] A rough indicator of this is an 11% increase in E/K ratio during the period of our study.

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Appendices

Appendix A: WPI Series used for Deflating Output

Industry	WPI used for deflating output
1. Aluminium	Aluminium
2. Cement	Cement
3. Fertilisers	Fertilisers
4. Glass and Glass Products	Glass, Earthenware, Chinaware and their products
5. Iron and Steel	Iron, Steel and Ferro Alloys
6. Paper and paper products	Paper and paper products
7. Total Manufacturing	Manufactured Products

Appendix B: Components of Material Inputs

Industry	Material Inputs
1. Aluminium	Primary products
	Paper and paper products
	Other Chemicals
	Non-ferrous metals
2. Cement	Non-metallic minerals
	Textiles
	Iron and Steel
	Other non-electric machinery
3. Fertilisers	Non-metallic minerals
	Textiles
	Fertilisers and pesticides
	Other Chemicals
4. Glass	Non metallic minerals
	Cement
	Iron and Steel
	Paper and paper products
	Other chemicals
5. Iron and Steel	Primary products
	Iron ore
	Other metallic mineral
	Non-metallic minerals
	Other chemicals
	Iron and Steel
	Non-ferrous metals
6. Paper and paper products	Primary products
	Paper and paper products
	Other chemicals
	Non-ferrous metals

Appendix C: Tables of Output and Input Indices

Aggregate Manufacturing

Year	Output	GVA	Capital	Labour	Energy	Materials
1973	100	100	100	100	100	100
1974	110.5	106.0	86.7	104.0	98.5	99.7
1975	125.0	111.3	92.0	109.6	118.4	118.4
1976	139.4	124.1	107.5	114.2	128.5	126.4
1977	155.3	135.2	127.9	121.9	135.3	137.7
1978	176.3	158.8	142.1	124.5	158.9	149.3
1979	173.1	150.5	144.2	131.9	168.9	144.6
1980	170.0	139.6	146.6	135.0	169.0	146.5
1981	194.5	159.9	155.1	135.6	173.7	162.4
1982	220.0	176.9	178.2	140.3	202.0	182.2
1983	224.9	204.8	203.5	137.4	230.8	189.0
1984	237.2	203.0	218.4	137.1	259.2	199.4
1985	255.0	212.7	221.2	130.3	280.2	229.9
1986	271.9	223.5	236.0	129.7	287.9	246.3
1987	293.5	238.8	265.0	135.8	330.9	263.3
1988	321.0	263.4	264.0	135.0	310.4	295.4
1989	361.2	295.1	287.5	141.9	378.3	343.1
1990	390.8	322.1	331.4	142.3	393.5	363.6
1991	388.3	311.1	325.8	142.9	400.1	365.0
1992	431.4	363.1	373.7	151.8	452.9	427.7
1993	462.2	412.4	421.5	151.8	425.4	451.3

Cement

Year	Output	Capital	Labour	Energy	Materials
1973	100	100	100	100	100
1974	95.3	83.9	99.6	82.3	89.2
1975	108.3	87.4	100.5	108.6	110.5
1976	121.2	93.3	100.4	120.0	123.4
1977	132.4	96.9	102.9	117.5	124.5
1978	129.3	105.0	105.9	129.5	128.8
1979	121.5	110.7	110.3	129.0	123.4
1980	136.9	142.5	133.3	118.4	130.3
1981	139.7	171.7	124.1	126.7	140.9
1982	186.4	219.5	139.5	165.9	191.8
1983	188.7	313.3	140.8	198.4	205.8
1984	226.2	314.3	149.4	247.4	253.8
1985	276.3	474.6	157.4	278.8	285.3
1986	316.4	602.6	159.4	324.2	290.7
1987	335.6	674.5	162.6	347.7	269.5
1988	432.8	715.1	165.4	421.5	318.6
1989	455.4	682.3	175.7	462.0	324.5
1990	506.0	688.8	168.2	500.8	348.1
1991	563.5	675.3	168.3	542.9	356.3
1992	560.8	695.1	187.1	593.4	399.6
1993	568.4	793.4	185.2	559.1	367.1

Fertilizer

Year	Output	Capital	Labour	Energy	Materials
1973	100	100	100	100	100
1974	98.1	101.1	109.8	98.9	112.8
1975	109.6	122.7	118.4	129.7	138.7
1976	138.1	127.4	116.1	162.7	147.7
1977	165.8	155.8	119.3	198.2	165.2
1978	204.6	164.3	125.8	228.9	187.7
1979	267.3	203.2	164.3	237.4	218.3
1980	217.0	174.0	156.0	205.4	216.3
1981	269.5	178.0	142.8	276.0	269.9
1982	295.7	152.1	146.0	288.8	290.6
1983	342.6	185.5	164.2	372.3	316.6
1984	366.8	144.1	137.1	351.4	315.6
1985	375.1	182.0	158.1	324.9	345.1
1986	429.6	189.9	139.5	447.8	411.3
1987	469.0	195.0	154.1	517.7	373.8
1988	568.1	204.4	167.5	430.9	415.5
1989	801.6	257.8	184.6	632.6	590.5
1990	866.2	237.0	171.4	537.0	607.2
1991	933.0	265.5	164.9	588.6	729.7
1992	854.3	255.9	198.3	622.6	723.3
1993	754.5	295.3	183.7	522.1	647.7

Glass

Year	Output	Capital	Labour	Energy	Materials
1973	100	100	100	100	100
1974	89.7	92.8	107.2	110.2	91.4
1975	81.0	83.4	104.4	109.9	79.7
1976	98.3	99.1	102.9	119.6	87.8
1977	103.5	90.8	95.3	116.7	89.5
1978	104.9	96.2	106.4	134.9	100.1
1979	95.3	73.8	108.3	125.2	87.3
1980	98.2	73.7	111.4	114.2	94.5
1981	128.7	96.7	118.7	148.9	118.0
1982	139.9	135.4	124.9	159.0	113.8
1983	142.5	116.5	115.8	164.3	109.3
1984	150.4	109.3	101.7	166.5	112.8
1985	189.1	131.8	106.2	188.8	141.9
1986	172.0	118.6	95.1	188.5	150.3
1987	175.1	139.3	96.1	194.3	158.9
1988	184.0	190.1	100.2	198.2	163.9
1989	296.1	308.5	107.4	300.3	254.4
1990	255.2	195.0	100.1	234.0	223.5
1991	388.0	336.7	123.7	343.6	317.3
1992	317.1	322.0	109.2	263.8	248.8
1993	358.4	613.4	108.5	263.6	279.9

Iron and Steel

Year	Output	Capital	Labour	Energy	Materials
1973	100	100	100	100	100
1974	107.4051	71.01792	86.64565	95.75928	92.16733
1975	131.1122	136.923	109.1508	127.5321	106.735
1976	139.9279	153.9682	106.9113	133.5603	112.1304
1977	152.1092	166.8779	116.0799	112.422	137.0349
1978	177.6537	173.7653	125.5658	200.9689	152.1497
1979	184.2877	199.434	127.145	201.9173	175.2663
1980	212.6463	206.3024	134.2924	187.8716	197.7975
1981	234.6286	235.9713	141.5774	176.7181	276.7273
1982	264.4576	269.5283	138.4735	189.5839	265.9042
1983	244.0578	300.5512	142.7756	225.6116	294.7917
1984	280.5196	339.6681	166.9322	253.7872	364.8564
1985	254.8053	317.3113	143.9829	243.3267	342.9763
1986	281.4334	318.2856	151.7893	244.7154	401.0395
1987	303.0283	321.0307	154.3804	263.5761	416.1668
1988	340.7922	304.728	149.8582	277.823	446.183
1989	327.4803	304.6588	137.1364	297.2931	460.1502
1990	417.6549	574.6211	160.6491	327.6698	505.2273
1991	370.683	543.2197	134.3469	307.0748	535.3148
1992	468.6887	610.0506	165.1887	362.9469	644.6842
1993	454.9805	714.5951	156.4231	338.0726	595.7971

Paper and paper products

Year	Output	Capital	Labour	Energy	Materials
1973	100	100	100	100	100
1974	112.4	100.8	103.9	98.3	101.0
1975	112.6	104.0	107.7	110.9	101.7
1976	117.7	122.0	111.2	118.3	110.5
1977	130.2	138.3	121.9	146.8	121.7
1978	129.4	137.4	117.5	141.3	124.5
1979	142.6	145.5	132.3	165.8	140.4
1980	151.7	193.3	138.1	170.3	149.4
1981	166.7	212.1	145.7	185.2	163.4
1982	153.3	257.3	156.8	197.9	160.0
1983	165.0	313.2	148.2	220.5	167.8
1984	197.4	387.9	146.0	264.9	198.5
1985	187.4	248.8	138.7	257.7	206.6
1986	204.0	324.6	142.2	289.4	211.8
1987	202.2	330.8	147.8	312.7	214.4
1988	221.4	382.3	142.1	331.9	233.3
1989	269.8	312.5	149.2	401.7	283.2
1990	302.7	368.5	157.9	403.4	317.6
1991	285.7	348.1	160.5	443.5	303.4
1992	266.5	368.1	170.4	447.8	291.4
1993	285.8	461.1	171.5	409.8	306.6

Appendix D: Tables of Partial Productivity Indices

Aluminium

Year	Capital	Labour	Energy	Materials	K/L
1973	1	1	1	1	1
1974	0.8634	0.9959	1.2062	1.0930	1.1534
1975	0.7065	0.8399	0.6637	0.9587	1.1888
1976	0.7629	1.0883	0.6149	0.9963	1.4265
1977	0.7035	0.9698	0.5683	0.9724	1.3786
1978	0.8140	1.0105	0.5378	1.0044	1.2413
1979	1.3571	0.9374	0.5022	0.9905	0.6908
1980	0.8962	0.8519	0.5021	0.8704	0.9505
1981	0.9512	0.8635	0.4758	0.8271	0.9078
1982	1.1404	1.0286	0.5133	0.8624	0.9020
1983	1.1954	1.0036	0.4992	0.9015	0.8396
1984	1.5638	1.2290	0.4658	0.8967	0.7859
1985	1.4388	1.2350	0.4408	0.9169	0.8583
1986	1.5956	1.2734	0.4684	0.8846	0.7981
1987	0.4875	1.3414	0.4897	0.9412	2.7518
1988	0.6209	1.5617	0.5539	1.0403	2.5152
1989	0.6919	1.7583	0.4589	1.1058	2.5413
1990	1.0035	1.5783	0.4640	0.9655	1.5727
1991	0.8907	1.7857	0.4619	1.1061	2.0048
1992	0.7547	1.8895	0.5545	1.0450	2.5037
1993	0.6765	1.8414	0.6883	0.9799	2.7220

Cement

Year	Capital	Labour	Energy	Materials	K/L
1973	1	1	1	1	1
1974	1.135	0.956	1.158	1.068	0.842
1975	1.240	1.078	0.997	0.980	0.869
1976	1.299	1.207	1.010	0.982	0.929
1977	1.365	1.286	1.126	1.063	0.942
1978	1.231	1.221	0.999	1.004	0.992
1979	1.098	1.102	0.942	0.985	1.004
1980	0.961	1.028	1.157	1.051	1.070
1981	0.814	1.126	1.103	0.991	1.383
1982	0.849	1.336	1.124	0.972	1.573
1983	0.602	1.340	0.951	0.917	2.224
1984	0.720	1.515	0.915	0.892	2.104
1985	0.582	1.755	0.991	0.968	3.014
1986	0.525	1.985	0.976	1.088	3.781
1987	0.498	2.064	0.965	1.245	4.148
1988	0.605	2.617	1.027	1.358	4.323
1989	0.668	2.593	0.986	1.404	3.884
1990	0.735	3.009	1.010	1.454	4.096
1991	0.834	3.348	1.038	1.582	4.012
1992	0.807	2.997	0.945	1.403	3.715
1993	0.716	3.069	1.017	1.548	4.283

Fertilizer

Year	Capital	Labour	Energy	Materials	K/L
1973	1	1	1	1	1
1974	0.971	0.893	0.993	0.870	0.920
1975	0.893	0.926	0.845	0.790	1.037
1976	1.084	1.189	0.849	0.935	1.097
1977	1.064	1.390	0.837	1.004	1.306
1978	1.245	1.626	0.894	1.090	1.306
1979	1.315	1.627	1.126	1.224	1.237
1980	1.247	1.391	1.056	1.003	1.116
1981	1.514	1.887	0.976	0.999	1.246
1982	1.944	2.025	1.024	1.018	1.042
1983	1.847	2.087	0.920	1.082	1.130
1984	2.546	2.676	1.044	1.162	1.051
1985	2.060	2.373	1.154	1.087	1.151
1986	2.263	3.079	0.959	1.045	1.361
1987	2.405	3.043	0.906	1.255	1.265
1988	2.779	3.392	1.318	1.367	1.220
1989	3.110	4.343	1.267	1.358	1.396
1990	3.655	5.052	1.613	1.426	1.382
1991	3.514	5.657	1.585	1.279	1.610
1992	3.339	4.307	1.372	1.181	1.290
1993	2.555	4.107	1.445	1.165	1.608

Glass

Year	Capital	Labour	Energy	Materials	K/L
1973	1	1	1	1	1
1974	0.966	0.836	0.814	0.981	0.866
1975	0.971	0.775	0.737	1.016	0.799
1976	0.992	0.955	0.822	1.119	0.963
1977	1.141	1.086	0.887	1.156	0.952
1978	1.090	0.986	0.777	1.048	0.904
1979	1.292	0.881	0.761	1.092	0.682
1980	1.332	0.882	0.860	1.039	0.662
1981	1.332	1.085	0.865	1.091	0.814
1982	1.034	1.120	0.880	1.229	1.084
1983	1.223	1.230	0.867	1.303	1.006
1984	1.376	1.479	0.903	1.333	1.075
1985	1.435	1.782	1.002	1.333	1.241
1986	1.450	1.809	0.912	1.144	1.248
1987	1.257	1.821	0.901	1.102	1.449
1988	0.968	1.837	0.928	1.123	1.898
1989	0.960	2.757	0.986	1.164	2.873
1990	1.308	2.549	1.090	1.142	1.948
1991	1.152	3.138	1.129	1.223	2.723
1992	0.985	2.905	1.202	1.274	2.950
1993	0.584	3.304	1.360	1.281	5.655

Iron and Steel

Year	Capital	Labour	Energy	Materials	K/L
1973	1.299288	0.471638	9.442473	1.794151	0.362997
1974	1.964999	0.584638	10.59083	2.090773	0.297526
1975	1.244148	0.566532	9.707548	2.203917	0.455358
1976	1.180807	0.61729	9.892653	2.238928	0.52277
1977	1.184301	0.618026	12.77585	1.991514	0.521849
1978	1.328363	0.667285	8.347012	2.094894	0.502337
1979	1.200611	0.683605	8.618038	1.8865	0.569381
1980	1.339241	0.746818	10.68765	1.928839	0.557643
1981	1.291894	0.78162	12.53677	1.521205	0.605019
1982	1.274844	0.900737	13.17166	1.78439	0.706547
1983	1.055066	0.806208	10.2145	1.485376	0.764131
1984	1.073035	0.792559	10.43709	1.379431	0.738615
1985	1.043346	0.834653	9.887905	1.332917	0.799978
1986	1.148852	0.874466	10.85926	1.259063	0.761165
1987	1.226428	0.925763	10.85583	1.306395	0.754845
1988	1.453057	1.07255	11.58263	1.370362	0.738134
1989	1.396615	1.126266	10.40126	1.276863	0.806425
1990	0.944368	1.226162	12.03558	1.483166	1.298394
1991	0.88661	1.301318	11.39841	1.242374	1.467746
1992	0.998215	1.338175	12.19347	1.304357	1.340568
1993	0.827252	1.37183	12.70774	1.370103	1.658297

Paper and paper products

Year	Capital	Labour	Energy	Materials	K/L
1973	1	1	1	1	1
1974	1.115	1.082	1.143	1.113	0.970
1975	1.082	1.045	1.015	1.107	0.966
1976	0.965	1.059	0.995	1.065	1.097
1977	0.941	1.069	0.887	1.070	1.135
1978	0.942	1.101	0.916	1.040	1.169
1979	0.980	1.077	0.860	1.015	1.100
1980	0.785	1.099	0.891	1.016	1.400
1981	0.786	1.145	0.900	1.020	1.456
1982	0.596	0.977	0.775	0.958	1.640
1983	0.527	1.113	0.748	0.983	2.113
1984	0.509	1.352	0.745	0.995	2.658
1985	0.753	1.351	0.727	0.907	1.794
1986	0.628	1.435	0.705	0.963	2.283
1987	0.611	1.368	0.647	0.943	2.238
1988	0.579	1.558	0.667	0.949	2.689
1989	0.863	1.808	0.672	0.953	2.095
1990	0.822	1.918	0.751	0.953	2.334
1991	0.821	1.780	0.644	0.942	2.169
1992	0.724	1.565	0.595	0.915	2.161
1993	0.620	1.666	0.697	0.932	2.688

Appendix E: Tables of Total Productivity Indices

Aluminium

Year	Translog	Solow	Kendrick
1973	1	1	1
1974	1.06	1.05	1.05
1975	0.85	0.80	0.84
1976	0.88	0.84	0.87
1977	0.84	0.80	0.83
1978	0.87	0.83	0.85
1979	0.93	0.88	0.89
1980	0.82	0.74	0.78
1981	0.79	0.71	0.76
1982	0.85	0.77	0.82
1983	0.87	0.78	0.84
1984	0.89	0.80	0.86
1985	0.87	0.79	0.85
1986	0.89	0.80	0.86
1987	0.79	0.63	0.74
1988	0.91	0.75	0.86
1989	0.93	0.76	0.86
1990	0.97	0.78	0.86
1991	1.01	0.82	0.91
1992	0.98	0.79	0.91
1993	0.97	0.78	0.90

Cement

Year	Translog	Solow	Kendrick
1973	1	1	1
1974	1.085162	1.072184	1.085363
1975	1.043738	1.020753	1.038843
1976	1.070122	1.048666	1.06318
1977	1.156599	1.135227	1.151447
1978	1.065255	1.039401	1.063934
1979	1.004713	0.979137	1.007874
1980	1.047276	1.015567	1.049008
1981	0.980935	0.942877	0.982373
1982	1.00208	0.966884	1.002385
1983	0.846947	0.776652	0.86213
1984	0.884167	0.81208	0.894005
1985	0.880192	0.797846	0.896556
1986	0.896455	0.808902	0.912007
1987	0.926938	0.836446	0.939899
1988	1.043545	0.956381	1.069538
1989	1.070675	0.979471	1.108959
1990	1.13399	1.038009	1.174987
1991	1.234795	1.130347	1.278063
1992	1.137925	1.038112	1.172612
1993	1.166546	1.056493	1.195542

Fertilizer

Year	Translog	Solow	Kendrick
1973	1	1	1
1974	0.911034	0.900765	0.908731
1975	0.832913	0.806611	0.831044
1976	0.979482	0.958772	0.978992
1977	1.020151	1.003404	1.021799
1978	1.133592	1.125696	1.133932
1979	1.261491	1.272492	1.261601
1980	1.097841	1.115888	1.090764
1981	1.165184	1.19026	1.145972
1982	1.281719	1.300112	1.22825
1983	1.286574	1.300723	1.251894
1984	1.499157	1.488213	1.424751
1985	1.381133	1.347216	1.323099
1986	1.355642	1.318008	1.292943
1987	1.501767	1.457429	1.462349
1988	1.747921	1.704752	1.674808
1989	1.802128	1.776083	1.70273
1990	2.0141	1.97605	1.866068
1991	1.878757	1.822035	1.714919
1992	1.720336	1.666348	1.571999
1993	1.586959	1.532047	1.501724

Glass

Year	Translog	Solow	Kendrick
1973	1	1	1
1974	0.92	0.92	0.91
1975	0.90	0.90	0.89
1976	1.00	1.01	0.99
1977	1.09	1.09	1.08
1978	0.99	0.98	0.98
1979	1.03	1.02	1.00
1980	1.05	1.03	1.02
1981	1.10	1.09	1.08
1982	1.09	1.07	1.08
1983	1.17	1.14	1.16
1984	1.25	1.22	1.25
1985	1.33	1.31	1.33
1986	1.23	1.21	1.22
1987	1.17	1.15	1.17
1988	1.11	1.08	1.11
1989	1.20	1.20	1.19
1990	1.31	1.28	1.29
1991	1.34	1.32	1.33
1992	1.32	1.30	1.30
1993	1.19	1.09	1.12

Iron and Steel

Year	Translog	Solow	Kendrick
1973	1	1	1
1974	1.24	1.19	1.24
1975	1.11	0.99	1.12
1976	1.12	1.00	1.13
1977	1.09	0.97	1.10
1978	1.10	0.97	1.12
1979	1.02	0.90	1.04
1980	1.10	0.97	1.12
1981	0.99	0.83	0.99
1982	1.08	0.91	1.11
1983	0.89	0.74	0.92
1984	0.86	0.71	0.88
1985	0.84	0.69	0.86
1986	0.84	0.69	0.86
1987	0.87	0.72	0.90
1988	0.95	0.78	0.97
1989	0.90	0.74	0.91
1990	0.90	0.75	0.93
1991	0.80	0.66	0.82
1992	0.85	0.72	0.88
1993	0.85	0.71	0.86

Paper and paper products

Year	Translog	Solow	Kendrick
1973	1	1	1
1974	1.11	1.11	1.11
1975	1.08	1.08	1.08
1976	1.03	1.02	1.02
1977	1.01	1.00	1.01
1978	1.00	0.99	1.00
1979	0.99	0.98	0.99
1980	0.94	0.92	0.92
1981	0.95	0.92	0.93
1982	0.83	0.79	0.79
1983	0.83	0.79	0.76
1984	0.84	0.81	0.76
1985	0.87	0.82	0.86
1986	0.86	0.82	0.83
1987	0.83	0.79	0.80
1988	0.84	0.80	0.79
1989	0.94	0.88	0.94
1990	0.94	0.89	0.93
1991	0.91	0.86	0.91
1992	0.85	0.80	0.84
1993	0.85	0.80	0.82

Table F: Table of Total Factor Productivity Indices

Aggregate Manufacturing

Year	Translog	Solow	Kendrick
1973	100	100	100
1974	112.7	111.3	112.1
1975	111.7	110.3	111.2
1976	112.3	111.1	112.2
1977	107.9	105.9	108.0
1978	118.3	116.8	118.5
1979	108.5	106.8	108.6
1980	98.7	97.0	98.8
1981	109.3	107.8	109.4
1982	109.8	108.1	110.0
1983	118.6	117.3	118.3
1984	112.8	111.1	112.1
1985	119.8	118.0	118.5
1986	121.4	119.4	119.4
1987	118.8	116.6	116.0
1988	131.6	129.2	128.6
1989	137.2	135.1	133.7
1990	136.3	134.0	131.7
1991	132.9	130.7	128.6
1992	138.7	136.8	133.5
1993	144.7	143.5	138.5